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PROMOTION OF THE MECHANIC ARTS.

JUNE, 1851.

## CIVIL ENGINEERING.

To the Committee of Publication of the Journal of the Franklin Institute.

Gentlemen:—This paper on curves has been prepared for publication in your Journal, in order to remove a difficulty under which young Assistant Engineers labor, from the want of such instructions and tables as it contains. I know of no work on the subject adapted to meet their necessities, and hope that this may be found to do so.

JOHN C. TRAUTWINE.

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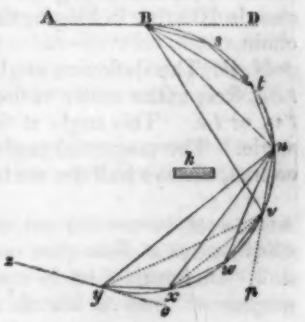
### ON THE FIELD PRACTICE OF LAYING OUT CIRCULAR CURVES FOR RAILROADS.—By JOHN C. TRAUTWINE, C. E.

#### ART. I.—PRINCIPLES OF LAYING OUT CURVES.

*Method 1st.—To Lay Out a Curve by Means of Tangential Angles.*

If from any point B, fig. 1, in a straight line A D, we lay off with an instrument any number of equal angles, as D B *s*, *s* B *t*, *t* B *u*, *u* B *v*, &c., and at the same time make the chords B *s*, *s t*, *t u*, *u v*, &c., equal to each other, then the points B, *s*, *t*, *u*, *v*, &c., will be situated in the circumference of a circle, which is tangential to the line A D at the point B.

Fig. 1.




The first of these angles D B *s*, is called the *tangential angle*, as being that by which the curve is connected with the tangent; but inasmuch as the others are all equal to it, they also are called tangential angles.

If any obstacle, as *h*, should prevent our seeing from B, farther than to *v*, the curve may be continued by removing the instrument to *u*, the point preceding *v*; thence sighting first on *v*, continue to lay off additional tangential angles *v u w*, *w u x*, &c., as before. Or else, moving the instrument to *v* itself instead of to *u*, sight back to *u*, and lay off first the exterior angle *p v w*, *double* the tangential angle, and afterwards continue the tangential angles *w v x*, *x v y*, &c., as before, to the end of the curve.

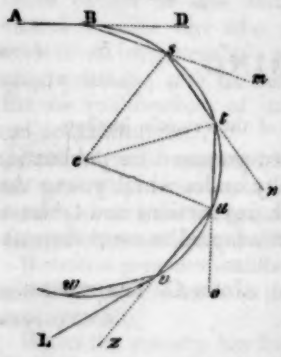
Finally, in order to pass from the end of the curve at *y*, on to a tangent *y z*, place the instrument at *y*, and sighting back to *x*, lay off the tangential angle *x y o*; then *o y* continued towards *z* will be the required tangent. (See Art. IV.)

## Article II.

### *Method 2d.—To Lay Out a Curve by Means of Deflexion Angles.*

Fig 2. First, having, as in method 1st, laid off a tangential angle D B *s*, and measured the chord B *s*, remove the instrument to the end *s* of the chord, and make the exterior angle *m s t* equal to *twice* the tangential angle, and measure the chord *s t*, and so on at the other points *t*, *u*, *v*, &c., making each of the exterior angles *n t u*, *o u v*, &c., equal to twice the tangential angle, and all the chords equal; then will the points B, *s*, *t*, *u*, *v*, &c., be in the circumference of a circle which is tangential to the line A D at the point B, as by the first method.

Fig. 2.




But, if at any of these points, as *v*, we wish to pass off to a tangent *v* L, employ at that point, the tangential angle *z v* L, equal to half the deflexion angle *z v w*. (See Art. IV.)

These exterior angles, included between any *chord* and the extension of the preceding *chord*, are called *deflexion angles*, or *angles of deflexion*, or *angles of curvature*. In any given circle, the angle of deflexion is precisely double that of the tangential angle, supposing the chords to be equal. We give tables of the angles corresponding to circles of different radii, embracing the limits of railroad practice, and calculated for chords 100 feet in length, that being a convenient length for a measuring chain.

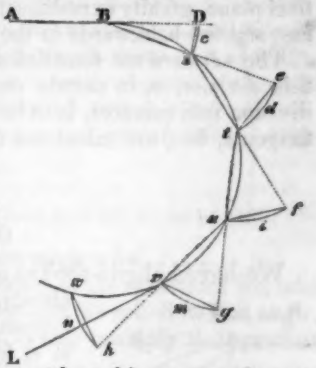
N. B. The deflexion angle of any curve is equal to the angle *t c u*, or *t c s*, &c., at the centre of the circle, subtended by one of the equal chords *t u*, or *t s*. This angle at the centre, so subtended, is called the *central* angle. The tangential angle being always half the deflexion angle, is, of course, always half the central angle.

## Article III.

### *Method 3d.—To Lay Out a Curve by Eye.*

The *deflexion* angles, fig. 3, *e s t*, *f t u*, *g u v*, *h v w*, &c., being double, the *tangential* angle D B *s*, the *arcs e d t*, *f i u*, *g m v*, *h n w*, &c., are double the *arc* D *c s*, since the arcs of circles are proportionate to the angles which they subtend; but the *chords e t*, *f u*, *g v*, *h w*, &c., are *not* double the *chord* D *s*, since the chords of arcs are not proportionate to the arcs, or to the angles which they subtend.

Fig 3.




The chords *e t*, *f u*, *g v*, *h w*, &c., which subtend the deflexion angles, are called *deflexion distances;* and the chord D *s*, which subtends the tangential angle, is called the *tangential distance.*

But, although, in any given circle, the deflexion distance is not *truly* twice the tangential distance; yet, the difference is so trifling in large railroad curves, with chords of but 100 feet that it may generally be neglected in curves of more than 300 feet radius.

In our tables the *precise* length of both will be found for different radii.

Having these respective distances, we may frequently trace a curve on the ground by the eye only, with very tolerable accuracy, sufficient for guiding the excavations and embankments, especially on nearly level ground. Suppose, for instance, it be required to lay out in this manner a curve of 5730 feet radius.

First, find by the table, the deflexion distance corresponding to a radius of 5730 feet for a chord of 100 feet, viz.: 1·745 feet; and also the tangential distance ·873 of a foot.

Then from the starting point B, and in line with A B, measure B D equal 100 feet; and put a temporary peg at D. Also from B, measure the chord B *s*, equal 100 feet; at the same time measuring with a graduated rod, from the peg D, the tangential distance D *s*, equal to ·873 of a foot; and place a stake at *s*. The peg at D may then be removed.

Next, make *s e* equal 100 feet, placing a temporary peg at *e*, precisely in line with *s* B; also from *s*, measure *s t* equal 100 feet; at the same time measuring with the rod, from the peg *e*, the *deflexion* distance *e t*, equal to 1·745 feet. Place a stake at *t*, and remove the temporary peg at *e*. In this manner proceed to find other points as far as the end of the curve at *v*.

In order to pass from the curve at *v*, to a tangent *v* L, proceed as before, only using the tangential distance *h n*, instead of the deflexion distance *h w*. (See Art. IV.)

This method is abundantly accurate for laying out curves on a canal or common road; and will occasionally answer very well, when carefully performed, for railroad curves, in the absence of an instrument. Thin straight rods, iron pointed, and a plumb line should be used for ranging the points, in the latter case.

The transit instrument is the best for tracing curves, and running lines generally. I prefer the graduations to run from the same zero, right and left, to 180° each way. There should be two verniers, graduated to minutes; by their means half or even quarter minutes may generally be estimated with considerable certainty. The telescope revolving in a vertical plane, greatly expedites the laying off of exterior angles, after having first sighted backwards to the point behind.

The verniers are sometimes graduated to hundredths of a degree; and this division is, in certain cases, the best; but for *general* purposes, the division into minutes, is to be preferred, as all the printed tables of sines, tangents, &c., are calculated for that division.

## Article IV.

### *On Sub-Chords.*

We have hitherto spoken of curves as if they were composed of equal chords, each of 100 feet in length. It frequently happens, however, that at the end of a curve, as at *e*, fig. 4, we are obliged to use a shorter or sub-chord *d e*, in order to unite properly with the tangent *e f*.

Fig. 4.

In that case, and *when using Method 1st, Art. I, of laying off curves by means of tangential angles*, we must, in order to fix the point *e*, lay off a *sub-tangential* angle *d A e*, as much smaller than the entire tangential angle B A *c*, or *c A d*, &c., as the sub-chord *d e* is smaller than an entire 100 feet chord, *a c*, *c d*, &c. Thus, if the sub-chord be one-half, or one-fourth, &c. of the entire chord, the sub-tangential angle must be one half, or one-fourth &c. of the entire tangential angle.

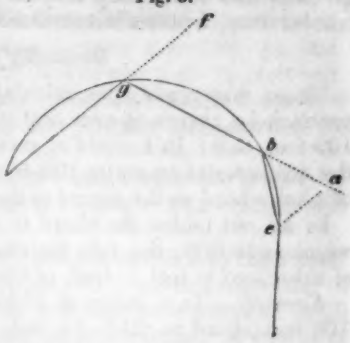
This method is not mathematically exact, for the reason stated in Art. III; yet, for curves of 300 or more feet radius, and with chords not exceeding 100 feet in length, the error is not observable in practice.

In like manner, when we pass off from a sub-chord, as at *e*, to a second tangent *e f*, we must place the instrument at *e*, and lay off the same sub-tangential angle *d e g*; or which is better, take sight from *e* to *c*, and lay off the angle *c e g*, equal to the *sum* of a tangential and the sub-tangential angle.

But, *when using Method 2d, Art. II, of laying out curves by means of deflexion distances, to calculate the sub-deflexion angle* a b e, *fig.* 5, *and sub-deflexion distance* a e, *formed between a sub-chord* b e, *and the extension* b a, *of an entire chord* g b, *with sufficient accuracy for curves of* 300 *or more feet radius, and chords of not more than* 100 *feet*,

*Rule.*—Say as an entire chord of 100 feet, is to the sub-chord *b e*, so is the deflexion angle of the curve to a certain angle. Add these two angles together and divide their sum by 2, for the deflexion angle of the sub-chord.

Fig. 5.




*Example.*—The curve, fig. 5, has a radius of 319·6 feet, and an angle of deflexion, *f g b*, of 18° for chords of 100 feet. The sub-chord *b e*, is 25 feet in length; what is the sub-deflexion *angle a b e*; and also the sub-deflexion *distance a e*, for the sub-chord *b e*?

| Chord | | Sub-chord |
|---|---|---|
| Here as 100 | is to | 25 |
| Def. Angle of 100 ft. chord, | | Certain Angle |
| So is 18° | to | 4° 30′. |

The sum of these two angles 18° and 4° 30′ = 22° 30′, the half of which is 11° 15′, the required sub-deflexion angle *a b e*.

Again, to find the sub-deflexion distance *a e*, of the sub-chord *b e*; take from the table of sines, the natural sine of one-half the sub-deflexion angle, just found. Multiply this natural sine by 2, and multiply that product by the length of the sub-chord.

*Example.*—The sub-deflexion angle is 11° 15′; one-half of it is 5° 37½′, the tabular natural sine of which is ·0979, which multiplied by 2, gives ·1958; and this multiplied by the sub-chord, 25 feet, gives 4·895 feet, the required sub-deflexion distance *a e*.

## Article V.

### *Ordinates for Entire Chords.*

It would be both tedious and liable to inaccuracy to attempt to fix all the necessary points in railroad curves by the foregoing means, which are employed only for entire chords, or for such sub-chords as may be required at the ends of curves.

The best method is to stretch a piece of twine *a b*, fig. 6, 100 feet long, between two adjacent chord stakes, and measure off as nearly as may be at right angles to it, with a graduated rod, the previously calculated ordinates *c d*, *e f*, *g h*, &c, placing pegs at *d*, *f*, *h*, &c. Our table of ordinates is calculated for distances apart *b c*, *c e*, *e g*, &c., of 5 feet; and for all curves likely to occur in practice. The 5 feet distances on the twine should be marked by knots or otherwise, and those at the centre, and half way between it and the ends, be further distinguished by tyeing on pieces of tape.

Fig. 6.

The 5 feet distances are only used (after the excavations and embankments are finished) for placing pegs to guide the laying of the rails, and then only for very sudden curves; for large ones, distances of 10 feet are quite sufficient, or even 25 feet for very easy curves. For guiding the curves of the cuttings and fillings, it is not necessary to place the stakes nearer than 50 feet apart; unless for those of less than about 1000 feet radius, when they may be placed 25 feet apart. Ordinates for radii intermediate of those in the table, may either be calculated by the rules

given further on, or they may be taken proportionally intermediate of the tabular ones, with sufficient accuracy for practice.

*Ordinates for Sub-Chords.*

These may readily be calculated *approximately enough for railroad practice*, for curves of over 300 feet radius, and for chords not exceeding 100 feet, thus: In a circle of given radius, not less than about 300 feet, the ordinates of an entire 100 feet chord may be assumed to be to those of a sub-chord as the square of the chord is to the square of the sub-chord.

In all our tables the chord is supposed to be 100 feet, the square of which is 10,000; the rule therefore becomes, as 10,000 feet : to square of sub-chord in feet :: Ord. of Chord : Ord. of Sub-chord *approximately.*

*Example.*—In a curve of 5730 feet radius, the middle ordinate of a 100 feet chord is ·218 of a foot; what will be the length of the middle ordinate of a sub-chord of 50 feet? here,

| Sq. of 100 ft. | | Sq. of 50 ft. | | Mid. Ord. of Chord. | | Mid. Ord. Sub-Chord *approximately.* |
|---|---|---|---|---|---|---|
| 10,000 | : | 2500 | :: | ·218 ft. | : | ·0545 ft. |

and so of any other ordinate, always supposing the chord and sub-chord to be divided into the *same number of parts.*

ARTICLE VI.

*Having given the angle* a b d, *fig.* 7, *it is required to find the point* a *or* d, *at which to commence a curve of given radius.*

Fig. 7.

*Rule.*—Subtract half the angle *a b d*, from 90°; the remainder will be the angle *b c a*, or *b c d.* From the table of tangents take the natural tangent of *b c a*, and multiply it by the given radius, the product will be *b a* or *b d.*

*Example.*—Let the angle *a b d* be 120°, how far from *b* must we begin, at *a* or *d*, to lay out a curve *a n d* of 2865 feet radius?

Here, half of the angle *a b d* = 60°, which taken from 90° leaves the angle *b c a* = 30°. The natural tangent of 30° = ·5773, which multiplied by the radius of 2865 feet, gives 1653·96 feet for *b a* or *b d.* (See Art. XII.)

ARTICLE VII.

*Having given the angle* a b d, *fig.* 7, *and the distance from* b *to* a *or* d, *at one of which we wish to commence a curve, it is required to find what radius* a c *or* c d, *the curve must have, in order to unite with* b a *and* b d *tangentially at* a *and* d.

*Rule.*—Subtract the angle *a b c*, which is half the angle *a b d*, from 90°; the remainder will be the angle *b c a*, or *b c d.* Then as nat. sine of *b c a*, or *b c d*, is to nat. sine of *a b c*, so is *a b* or *b d*, to *a c* or *c d* the radius required.

*Example.*—Let the angle *a b d* be 120°, and the distance *b a* or *b d*, 1654 feet; what will be the radius *a c* or *c d* of a circle that shall touch *a* and *d* tangentially?

Here, the angle *a b c* = half the angle *a b d*, is 60°, which taken from 90°, leaves the angle *b c a* or *b c d* = 30°. Then as the nat. sine of *b c a*

or *b c d* (30°) = ·5000, is to nat. sine of *a b c* or *d b c*, (60°) = ·8660, so is *b a* or *b d* (1654 feet) to *a c* or *c d*, 2865 feet, the radius required.

## Article VIII.

*Having given the radius* a c, *fig.* 7, *of a curve, and the angle* a b d, *it is required to find the number of chords of* 100 *feet that will constitute the curve.*

*Rule.*—Subtract the angle *a b d* from 180°, and divide the remainder by the angle of curvature, or deflexion of the curve. The quotient will be the required number of chords.

*Example.*—Let the angle *a b d* be 120°, and the radius *a c*, 2865 feet.

Here the angle *a b d*, 120°, subtracted from 180°, leaves a remainder of 60°; which, divided by 2°, the angle of deflexion for a curve of 2865 feet, gives a quotient of 30; which is the required number of chords of 100 feet.

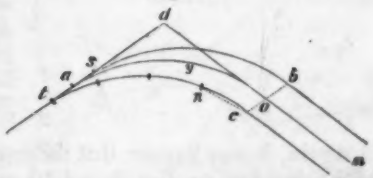
N. B.—Had the quotient contained a *fraction* of a chord, it would have indicated that we should have had to employ a sub-chord at the end of the curve; for instance, had the number of chords been 30½, a sub-chord of 50 feet would have been necessary.

## Article IX.

*How to proceed when the end of a curve does not correctly join the tangent.*

We sometimes find on running out a curve for the number of chords determined by the Rule in the preceding Article, that instead of uniting as it should with the previously determined tangent *o m*, fig. 8, at *o*, it ends tangentially to a line *parallel* to said tangent, either *within* it as at *c*; or *beyond* it as at *b*. Being first certain that no error has occurred in tracing out the curve, ascertain with the compass the bearing of the line *a d*, and removing the compass to the end of the curve at *c* or *b*, (as the case may be,) run the line *b o* or *c o*, in the same course as *a d*, until it strikes the tangent *d o m*; which may be ascertained by ranging two stakes placed on the tangent.

Fig. 8.




Then measure *b o* or *c o*, (as the case may be,) and if the curve fall *within* the tangent *o m*, as at *c*, measure forwards from *t* towards *d*, the distance *t a*, equal to *c o*; or if the curve fall beyond the tangent, as at *b*, measure backwards from *s*, the distance *s a* equal to *b o*. Then the curve retraced from *a*, will terminate tangentially in *d m* at *o*.

N. B.—The direction of *c o* or *b o* may be ascertained without a compass, and better, thus: Multiply the tangential angle of the curve by twice the number of chords run, less one; subtract the product from 180°, and sighting back one chord to *n*, lay off the angle *n c b*, equal to the remainder. For example, if the tangential angle be 10°, and from *t* to *c* be 4 chords, then 7 times 10° taken from 180° leaves the angle *n c b* = 110°. When the product exceeds 180°, it must be subtracted from 360°, for the angle *n c b*.

This case occurs whenever an error has been made in measuriug the distance from *d* to *a*. If *d a* be made too short, the curve *s b* is the result, and if too long, the curve *t c*.

If the error is small, it may be divided equally among the chords by measure, without retracing the curve with an instrument. This method may be employed with perfect security so long as the error does not exceed 1 foot to every chord of 100 feet; and it need never be greater if moderate care be taken.

Thus, if the curve be 20 chords long, and the error 20 feet, the last stake may be moved 20 feet, the next 19, the next 18, &c., as nearly at right angles to the curve as can be judged by eye.

The same ordinates that would have been used had the curve been correct, will answer for the one so adjusted, without perceptible difference. For other cases, see Article X.

## Article X.

Fig. 9.

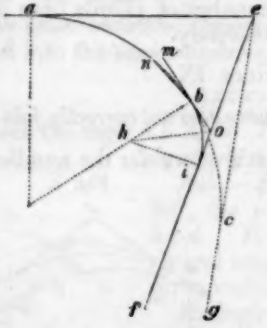
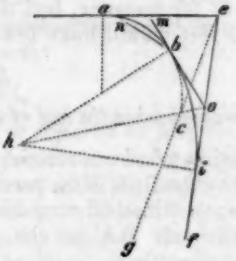



Fig. 10.




Again, it may happen that the error is not caused by a mismeasurement of the distance *a e*, figs. 9 and 10, as in the last case; but by a mistake in obtaining the angle *a e f*.

If *a e f*, fig. 9, be measured in excess, as *a e g*, then the curve *a b c*, calculated for the incorrect angle *a e g*, will be found to fall *beyond* the true tangent *e f*, as at *c*; and the tangents *e g* and *e f* not being parallel, the curve cannot be adjusted by either of the methods given in the preceding Article, unless the error be within about 1 foot to each 100 feet length of the curve; in which case, (supposing no other error to exist,) either of those methods may be employed, with sufficient accuracy for practice.

Also, if *a e f*, fig. 10, be measured too small, as *a e g*, then the curve *a b c*, calculated for the incorrect angle *a e g*, will be found to fall *within* the true tangent *e f*, as at *c*; when so, the remarks contained in the preceding sentence are equally applicable here. If the error be within 1 foot to 100 feet length of curve, it may be equally divided among the chords. But if greater, we must either re-measure the angle *a e f* correctly, and go over the whole work again, or resort to some other mode of obviating the difficulty. The angle *a e f* may be difficult of access, or the curve may be so long that to retrace it would be a work of much labor. We may then adopt the method of *compound curves*, by which much trouble will be

avoided, and a considerable portion of the first part of the curve be allowed to remain as it is.

Thus, whether the curve *a b c* fall beyond the true tangent *e f*, as in fig. 9, or inside of it, as in fig. 10, place the instrument at *b*, figs. 9 and 10, (the point at which the change of radius is to take place,) and sighting back one chord to *n*, lay off the tangential angle *n b m* of the curve *a b c*, and observe where the new tangent *m b* continued, strikes *e f*, as at *o*. Measure both *b o* and the angle *b o f*. Half the angle *b o f* taken from 90°, gives the angle *b h o*; then say, as the

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nat. Sine of angle *b h o*, opposite the given side *b o*, | is to | Nat Sine of angle *b o h* opposite the required side *b h*, | so is | The given side *b o*, | to | The required side, or new radius *b h*. |

Ascertain from the table or by calculation, the angle of deflexion, and the tangential angle corresponding to this new radius *b h*; and the new curve commenced *a b* will terminate tangentially to *e f* at *i*, as far from *o* as *o* is from *b*.

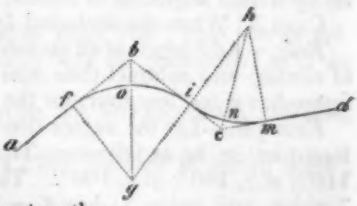
For the mode of uniting two curves at different radii, so as to form a compound curve, see Article XIII.

It will be observed, that when the first curve, *a b c*, fig. 10, falls inside the tangent *e f*, the new curve must be of *greater* radius; and when *beyond*, fig. 9, of a *less* one.

## Article XI.

*Having given the angles* a b c *fig.* 11, *and* b c d, *and the distance* b c, *it is required to find the greatest radius*, g i *or* h i, *that can be employed in a reverse curve*, f o i n m, *for uniting* a b *to* c d.

Fig. 11.




*Rule.*—Half the angle *a b c* taken from 90°, leaves the angle *b g i*; and half the angle *b c d* taken from 90°, leaves the angle *i h c*.

From the table of tangents take the natural tangent (*b i*) of angle *b g i*; and that (*i c*) of the angle *i h c*; and add them together.

Then as the sum of these two nat. tangents is to the nat. tang. of *b g i*, so is *b c* to *b i*; and *b i* taken from *b c*, gives *i c*.

Again, in the triangle *b g i*, as the nat. sine of the angle *b g i*, opposite the given side *b i*, just found, is to the nat. sine of the angle *g b i*, opposite the required side *g i*, so is *b i*, the given side, to *g i*, the required side or radius.

*Example.*—Let the angle *a b c* be 71° 40′, the angle *b c d* 129° 15′, and the distance *b c* 950 feet. What is the length of radius *h i* or *g i*, of the easiest reverse curve that can be traced for uniting *a b* to *c d*?

Here, half the angle *a b c* (35° 50′) taken from 90°, leaves the angle *b g i* 54° 10′, and half the angle *b c d* (64° 37½′) taken from 90°, leaves the angle *i h c* = 25° 22½′.

From the table of tangents, we have nat. tang. of *b g i* (54° 10′) = 1·3848; and nat. tang. of *i h c* (25° 22½′) = ·4743; their sum being 1·8591.

Then as

| | | | | | | |
|---|---|---|---|---|---|---|
| Sum of Tang's. 1·8591. | is to | Tang. of 54° 10′, 1·3848, | so is | *b c* 950 ft, | to | *b i* 707·63 ft. |

and *b i*, 707·63 feet, taken from *b c*, 950 feet, leaves *i c* 242·37 feet.

Again, as the

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nat. Sine of angle *b g i* ·8107 | is to | Nat. Sine of Angle *g b i* ·5854, | so is | *b i* 707.63 feet | to | *g i* or *h i*, the required radius, 510·97 feet. |

## Article XII.

*To obtain the angle* d b e, *formed by two tangents*, d b, *and* b e, *when the point* b *is inaccessible.* Figs. 12, 13, 14, and 15.

This is of frequent occurrence.

Case 1. When the included figure, fig. 12, has but *three* sides.

*Rule.*—Subtract the angle *a d e* from 180° for the angle *b d e*; and subtract the angle *d e c* from 180°, for the angle *d e b*. Add together *b d e*, and *d e b*, and subtract their sum from 180°, for the angle *d b e*.

Fig. 12. Fig. 13. Fig 14. Fig. 15.

Case 2. When the included figure, *d b e f*, figs. 13 and 14, has *four* sides.

*Rule.*—Subtract the sum of the three *internal* angles of the figure marked by dotted segments of circles, from 360°, for the angle *d b e*.

Case 3. When the included figure, fig. 15, has *more than four sides.*

*Rule.*—Add together all the *internal* angles, marked by dotted segments of circles; and subtract their sum from twice as many right angles as the figure has sides, less four, for the angle *d b e*.

*Example.*—Let the angles denoted by the dotted segments at the different letters be as follows: That at *d*, 70°; at *o*, 220°; at *i*, 150°; at *s* 110°; at *c*, 160°; at *e*, 100°. The sum of these is 810°. The figure has 7 sides, and twice 7, less 4 = 10; and 10 right angles = 900°; from which the sum of the designated internal angles (810°) being subtracted, leaves 90°, for the angle *d b e*.

N. B.—When the angle *d b e* has to be deduced from a figure of many sides, as fig. 15, the errors spoken of in Articles IX. and X. are apt to occur, unless the several sides and the angles *o*, *i*, *s*, &c., be measured with much care. For tracing curves with any accuracy and satisfaction, the instrument should be divided at least into minutes; as before remarked, the transit instrument is the best for the purpose. With moderate care in the preparatory measurement of the sides and angles, errors will seldom occur, that may not be adjusted with all the accuracy required in practice, by the very simple method of dividing them equally among the chords, as explained in Articles IX. and X.

## Article XIII.

*To pass from one curve* a m b, *fig.* 16, *to another* b n c, *of different radius, but running in the same direction, constituting a compound curve.*

*Rule.*—Placing the instrument at *b*, sight back to the other end of the 100 feet chord at *a;* and lay off the *tangential* angle *a b d*, of the curve *a m b;* then from the common tangent *d b e*, lay off the *tangential* angle *e b c*, of the curve *b n c*, making at the same time the chord *b c* equal to 100 feet.

Fig. 16.

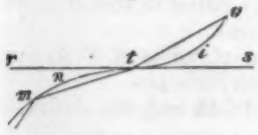
N. B.—If running the curve by eye, use the tangential *distances* instead of the angles.

## Article XIV.

*To pass from one curve,* m n t, fig. 17, *to another,* t i o, *of either the same, or of a different radius, but running in an opposite direction; constituting a reverse curve.*

*Rule.*—Placing the instrument at *t*, sight back to the other end of the 100 feet chord at *m*, and lay off the tangential angle *m t r*, of the curve *m n t;* then from the common tangent *r t s*, lay off the tangential angle *s t o*, of the curve *t i o;* making at the same time the chord *t o*, equal to 100 feet.

Fig. 17.




N. B.—If running the curve by eye, use the tangential *distances*, instead of the angles.

## Article XV.—Radii.

*To find the radius corresponding to any given angle of deflexion, and to equal chords of any given length.*

*Rule* 1. Subtract the angle of deflexion from 180°, then say as nat. sine of angle of deflexion, is to nat. sine of *half* the remainder, so is the given chord to the radius required.

*Example.*—Let the angle of deflexion be 2°, and the chord 100 feet, required the radius.

Here 2° subtracted from 180°, leaves 178°, the half of which is 89°, and as

| Nat. Sine of 2° | Nat. Sine of 89° | Chord | Radius |
|---|---|---|---|
| ·034899 | ·999848 | 100 feet | 2865 feet. |

*Rule* 2. The radius of 100 feet chords may be found *approximately*, by dividing 5730 by the deflexion angle. This rule is very close for radii of not less than 500 feet. For 500 feet it gives $\frac{8}{10}$ths of a foot too little; but is more approximate for larger radii.

*Example.*—What is the radius to a deflexion angle of 2°, the chords being 100 feet long?

Here, 5730 divided by 2, gives 2865 feet, the radius required.

## Article XVI.—Angles of Deflexion.

*To find the angle of deflexion to any given radius, and to equal chords of any given length.*

*Rule* 1. Divide *half* the chord by the radius; the quotient will be the natural sine of one-half the angle of deflexion. Therefore, *twice* the angle corresponding to this sine, in the table of natural sines, will be the angle of deflexion required. By this rule our table has been prepared.

*Example.*—Let the radius be 2865 feet, and the chord 100 feet; what will be the deflexion angle?

Here, half the chord, 50 feet, divided by the radius, 2865 feet, gives ·01745; and the angle in the table corresponding to the nat. sine ·01745 is 1°, twice which is 2°, the deflexion angle required.

*Rule* 2. The deflexion angle for 100 feet chords may be found approximately by dividing 5730 by the radius. This is very close for curves over 500 feet radius. For 500 feet, it gives about 1 minute too little.

*Example.*—What is the deflexion angle for a radius of 2865 feet, the chords being 100 each?

Here, 5730 divided by the radius 2865, gives 2°, the deflexion angle required.

### Article XVII.—Deflexion Distances.

*To find the deflexion distance (exactly) for any given radius, when the chords are 100 feet long.*

*Rule.*—Divide the constant number 10,000 by radius in feet; the quotient will be the deflexion distance required.

*Example.*—What is the deflexion distance to a radius of 5730 feet; the chords being 100 feet long?

Here, 10,000 divided by 5730 radius, gives 1·745 feet, the deflexion distance required.

*To find the deflexion distance for any given radius, and for equal chords of any given length.*

*Rule.*—Divide half the given chord by radius; the quotient will be the natural sine of one-*half* the deflexion angle; and *double* this natural sine, multiplied by the chord, will give the deflexion distance required. By this rule our table was prepared.

*Example.*—As before, what is the deflexion distance to a radius of 5730 feet; the chords being 100 feet long?

Here, half the chord, 50 feet, divided by radius 5730, gives ·008726, which is the natural sine of half the deflexion angle. Now, ·008726, multiplied by 2, gives ·017452, which multiplied by the chord, 100 feet, gives 1·745 feet, the required deflexion distance, the same as in the preceding example.

### Article XVIII.—Tangential Angles.

These may always be found by taking half the deflexion angle. See Article XVI.

### Article XIX.—Tangential Distances.

*To find the tangential distance corresponding to any given radius, and to equal chords of any given length.*

*Rule.*—First find the deflexion angle, by Article XVI, one-half of this angle will be the tangential angle. Take from the table of nat. sines, that corresponding to one-*half* of the *tangential* angle. Then multiply double this sine by the given chord, for the tangential distance. By this rule our table was prepared.

*Example.*—Let the radius be 2865 feet, and the chords 100 feet each; what will be the tangential distance?

Here, we find by Article XVI, the deflexion angle 2° for a radius of 2865 feet. Consequently the tangential angle, being one-half of this, is 1°.

The natural sine corresponding to 30 minutes, or one-half of this tangential angle, is by the table of sines, ·008727; the double of which is ·017454, which multiplied by the chord, or 100 feet, gives 1·745 feet for the tangential distance required.

## Article XX.—Ordinates.

*To find the middle ordinate to any given radius, and to any given chord.*

*Rule* 1.—From the square of the radius, subtract the square of half the chord; and take the square root of the remainder from the radius, for the middle ordinate.

*Example.*—What is the length of the middle ordinate *t*, fig. 6, Art. V, the radius being 819 feet, and the chord *a b* 100 feet?

Here, the square of 819 is 670761; and the square of 50, (half the chord,) is 2500; which, being subtracted from the former, leaves 668261; the square root of which is 817·472; which taken from the radius 819, leaves 1·528 feet, the required middle ordinate, *t*.

*Rule* 2.—Subtract the tabular cosine of half the angle of deflexion from 1; and multiply the remainder by the radius.

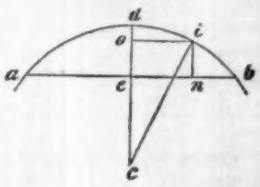
*Example.*—Same as foregoing, namely, radius 819 feet; angle of deflexion 7°, to chords of 100 feet. What will be the length of the middle ordinate?

Here, tabular cosine of $3\frac{1}{2}$° (one-half the angle of deflexion) is ·998135; which subtracted from 1, leaves ·001865; which multiplied by 819, the radius, gives 1·527, the middle ordinate required.

## Article XXI.

*Having given the middle ordinate* d e, *fig.* 18, *it is required to find any other one, as* i n.

Fig. 18.




*Rule* 1.—Having first found the middle ordinate *d e*, subtract it from the radius, the remainder will be *e c*; then from the square of the radius *c i*, subtract the square of the distance *o i*, which the required ordinate *i n*, is from the middle ordinate *d e*, and extract the square root of the remainder. This square root will be *o c*. From this square root *o c*, subtract *e c*; the remainder will be *o e*, which is equal to *i n*, the required ordinate.

*Example.*—The middle ordinate of a 100 feet chord to a radius of 819 being 1·528 feet, it is required to find the length of an ordinate 20 feet from the middle one.

Here, the middle ordinate *d e*, 1·528, subtracted from the radius 819, leaves *e c*, 817·472. The square of the radius is 670761; and the square of 20 (the distance of the required ordinate from the middle one) is 400; which taken from 670761, leaves 670361; the square root of which is 818·756 or *o c*; from which take *e c*, or 817·472, and the remainder 1·284 will be *o e*, which is equal to *i n*, the required ordinate.

***Rule* 2.**—Multiply the ordinates of a 1° curve by the deflexion angle of the curve whose ordinates are required, (chords being 100 feet.) This is a sufficiently close approximation for curves of not less than 500 feet radius; and for placing ordinates *for guiding the excavations and embankments*, it is close enough for the smallest curves in our table.

*Radii, &c., for Laying out Curves with a Chain or Chord of* 100 *feet. The Tangential Angle is always one-half of the Angle of Deflexion.*

| Angle of Defl'n. | Radius in feet. | Defl'n Distance in feet. | Tang'l Distance in feet. | Angle of Defl'n | Radius in feet. | Defl'n Distance in feet. | Tang'l Distance in feet. | Angle of Defl'n | Radius in feet. | Defl'n Distance in feet. | Tang'l Distance in feet. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ° ′ | | | | ° ′ | | | | ° ′ | | | |
| 5 | 68760 | ·145 | ·073 | 35 | 1599·0 | 6·253 | 3·127 | 15 | 433·4 | 23·07 | 11·56 |
| 10 | 34380 | ·291 | ·146 | 40 | 1563.0 | 6·398 | 3·199 | 30 | 425·5 | 23·51 | 11·77 |
| 15 | 22920 | ·436 | .218 | 45 | 1528·0 | 6·544 | 3·272 | 45 | 417·7 | 23·94 | 11·99 |
| 20 | 17190 | ·581 | ·291 | 50 | 1495·0 | 6·689 | 3·345 | 14 | 410·3 | 24·37 | 12·21 |
| 25 | 13752 | ·727 | ·364 | 55 | 1463·0 | 6·835 | 3·418 | 15 | 403·1 | 24·81 | 12·43 |
| 30 | 11460 | ·872 | ·436 | 4 | 1433·0 | 6·980 | 3·490 | 30 | 396·2 | 25·24 | 12·65 |
| 35 | 9823 | 1·017 | ·509 | 15 | 1348·0 | 7·416 | 3·708 | 45 | 389·6 | 25·67 | 12·86 |
| 40 | 8595 | 1·163 | ·582 | 30 | 1274·0 | 7·853 | 3·927 | 15 | 383·1 | 26·11 | 13·08 |
| 45 | 7640 | 1·308 | ·654 | 45 | 1207·0 | 8·289 | 4·145 | 15 | 376·9 | 26·52 | 13·30 |
| 50 | 6876 | 1·453 | ·727 | 5 | 1146·0 | 8·722 | 4·361 | 30 | 370·8 | 26·94 | 13·52 |
| 55 | 6251 | 1·600 | ·800 | 15 | 1092·0 | 9·159 | 4·579 | 45 | 365·0 | 27·37 | 13·73 |
| 1 | 5730 | 1·745 | ·873 | 30 | 1042·0 | 9·595 | 4·798 | 16 | 359·3 | 27·83 | 13·95 |
| 5 | 5289 | 1·890 | ·945 | 45 | 996·8 | 10·030 | 5·015 | 30 | 348·4 | 28·70 | 14·38 |
| 10 | 4912 | 2·036 | 1·018 | 6 | 955.4 | 10·470 | 5·235 | 17 | 338·3 | 29·56 | 14·82 |
| 15 | 4584 | 2·181 | 1·091 | 15 | 917·0 | 10·900 | 5·450 | 30 | 328·7 | 30·43 | 15·25 |
| 20 | 4298 | 2·327 | 1·164 | 30 | 882·0 | 11·340 | 5·670 | 18 | 319·6 | 31·29 | 15·69 |
| 25 | 4045 | 2·472 | 1·236 | 45 | 849·3 | 11·780 | 5·890 | 30 | 311·0 | 32·50 | 16·12 |
| 30 | 3820 | 2·618 | 1·309 | 7 | 819·0 | 12·210 | 6·105 | 19 | 302·9 | 33·01 | 16·56 |
| 35 | 3619 | 2·763 | 1·382 | 15 | 790·8 | 12·640 | 6·320 | 30 | 295·3 | 33·87 | 16·99 |
| 40 | 3438 | 2·908 | 1·454 | 30 | 764·5 | 13·080 | 6·540 | 20 | 287·9 | 34·73 | 17·43 |
| 45 | 3274 | 3·054 | 1·527 | 45 | 739·9 | 13·510 | 6·755 | 21 | 274·4 | 36·44 | 18·30 |
| 50 | 3125 | 3·199 | 1·599 | 8 | 716·8 | 13·950 | 6·975 | 22 | 262·0 | 38·15 | 19·17 |
| 55 | 2990 | 3·345 | 1·673 | 15 | 695·1 | 14·380 | 7·190 | 23 | 250·8 | 39·87 | 20·02 |
| 2 | 2865 | 3·490 | 1·745 | 30 | 674·6 | 14·810 | 7·405 | 24 | 240·5 | 41·58 | 20·91 |
| 5 | 2750 | 3·635 | 1·818 | 45 | 655·5 | 15·250 | 7·625 | 25 | 231·0 | 43·28 | 21·77 |
| 10 | 2644 | 3·781 | 1·891 | 9 | 637·3 | 15·680 | 7·840 | 26 | 222·3 | 44·98 | 22·64 |
| 15 | 2547 | 3·926 | 1·963 | 15 | 620·2 | 16.120 | 8·060 | 27 | 214·2 | 46·68 | 23·51 |
| 20 | 2456 | 4·072 | 2·036 | 30 | 603·8 | 16·550 | 8·275 | 28 | 256·7 | 48·38 | 24·37 |
| 25 | 2371 | 4·217 | 2·109 | 45 | 588·4 | 16·990 | 8·495 | 29 | 199·7 | 50·07 | 25·24 |
| 30 | 2292 | 4·363 | 2·182 | 10 | 573·7 | 17·430 | 8·715 | 30 | 193·2 | 51·76 | 26·11 |
| 35 | 2218 | 4·508 | 2·254 | 15 | 559·7 | 17·870 | 8·935 | 31 | 187·1 | 53·45 | 26·97 |
| 40 | 2149 | 4·653 | 2·327 | 30 | 546·4 | 18·300 | 9·150 | 32 | 181·4 | 55·13 | 27·83 |
| 45 | 2084 | 4·799 | 2·399 | 45 | 533·8 | 18·730 | 9·365 | 33 | 176·0 | 56·80 | 28·70 |
| 50 | 2023 | 4·944 | 2·472 | 11 | 521·7 | 19·170 | 9·585 | 34 | 171·0 | 58·47 | 29·56 |
| 55 | 1965 | 5·090 | 2·545 | 15 | 510·1 | 19·610 | 9·805 | 35 | 166·3 | 60·14 | 30·42 |
| 3 | 1910 | 5·235 | 2·618 | 30 | 499·1 | 20·050 | 10·030 | 36 | 161·8 | 61·80 | 31·29 |
| 5 | 1859 | 5·380 | 2·690 | 45 | 488.5 | 20·500 | 10·250 | 37 | 157·6 | 63·46 | 32·15 |
| 10 | 1810 | 5·526 | 2·763 | 12 | 478·3 | 20·940 | 10·470 | 38 | 153·6 | 65·11 | 33·01 |
| 15 | 1763 | 5·671 | 2·836 | 15 | 468·7 | 21·360 | 10·690 | 39 | 149·8 | 66·76 | 33·87 |
| 20 | 1719 | 5·817 | 2·909 | 30 | 459·3 | 21·790 | 10·900 | 40 | 146·2 | 68·40 | 34·73 |
| 25 | 1677 | 5·962 | 2·981 | 45 | 450·3 | 22·210 | 11·120 | | | | |
| 30 | 1637 | 6·108 | 3·054 | 13 | 441·7 | 22·640 | 11·340 | | | | |

*Ordinates for Laying Out Curves. Ordinates 5 feet apart. Chord 100 feet.*

| Deflexion Angle in degrees and minutes. | Distances of the Ordinates from the End of the 100 feet Chord. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Middle 50 feet. | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet. |
| | *Lengths of Ordinates in Feet.* | | | | | | | | | |
| ° ′ | | | | | | | | | | |
| 5 | ·018 | ·018 | ·017 | ·016 | ·015 | ·014 | ·012 | ·009 | ·006 | ·003 |
| 10 | ·036 | ·036 | ·035 | ·033 | ·031 | ·027 | ·023 | ·019 | ·013 | ·007 |
| 15 | ·054 | ·054 | ·052 | ·049 | ·046 | ·041 | ·035 | ·028 | ·019 | ·010 |
| 20 | ·073 | ·072 | ·070 | ·066 | ·061 | ·055 | ·047 | ·037 | ·026 | ·014 |
| 25 | ·091 | ·090 | ·087 | ·082 | ·076 | ·068 | ·058 | ·046 | ·032 | ·017 |
| 30 | ·109 | ·108 | ·105 | ·099 | ·092 | ·082 | ·070 | ·055 | ·039 | ·020 |
| 35 | ·127 | ·126 | ·123 | ·116 | ·108 | ·096 | ·082 | ·065 | ·045 | ·024 |
| 40 | ·145 | ·144 | ·140 | ·133 | ·123 | ·110 | ·093 | ·074 | ·052 | ·027 |
| 45 | ·163 | ·161 | ·157 | ·149 | ·137 | ·123 | ·105 | ·083 | ·058 | ·031 |
| 50 | ·182 | ·180 | ·175 | ·166 | ·153 | ·138 | ·117 | ·092 | ·065 | ·034 |
| 55 | ·200 | ·198 | ·192 | ·182 | ·168 | ·151 | ·128 | ·102 | ·071 | ·038 |
| 1 | ·218 | ·216 | ·209 | ·198 | ·183 | ·164 | ·140 | ·111 | ·078 | ·041 |
| 5 | ·236 | ·234 | ·226 | ·215 | ·198 | ·178 | ·152 | ·120 | ·085 | ·044 |
| 10 | ·254 | ·252 | ·244 | ·231 | ·214 | ·191 | ·163 | ·130 | ·091 | ·048 |
| 15 | ·273 | ·270 | ·261 | ·248 | ·229 | ·205 | ·175 | ·139 | ·098 | ·051 |
| 20 | ·291 | ·288 | ·279 | ·264 | ·244 | ·218 | ·187 | ·148 | ·104 | ·055 |
| 25 | ·309 | ·306 | ·296 | ·281 | ·259 | ·232 | ·198 | ·157 | ·111 | ·058 |
| 30 | ·327 | ·324 | ·314 | ·297 | ·275 | ·246 | ·210 | ·167 | ·117 | ·062 |
| 35 | ·345 | ·342 | ·331 | ·314 | ·290 | ·259 | ·221 | ·176 | ·124 | ·065 |
| 40 | ·364 | ·360 | ·349 | ·330 | ·305 | ·273 | ·233 | ·185 | ·130 | ·069 |
| 45 | ·382 | ·378 | ·366 | ·347 | ·321 | ·287 | ·245 | ·195 | ·137 | ·072 |
| 50 | ·400 | ·396 | ·384 | ·364 | ·336 | ·300 | ·256 | ·204 | ·144 | ·076 |
| 55 | ·418 | ·414 | ·401 | ·380 | ·351 | ·314 | ·268 | ·213 | ·150 | ·079 |
| 2 | ·436 | ·432 | ·419 | ·397 | ·366 | ·327 | ·280 | ·222 | ·157 | ·083 |
| 5 | ·454 | ·450 | ·436 | ·413 | ·382 | ·341 | ·291 | ·232 | ·163 | ·086 |
| 10 | ·473 | ·468 | ·454 | ·430 | ·397 | ·355 | ·303 | ·241 | ·170 | ·089 |
| 15 | ·491 | ·486 | ·471 | ·446 | ·412 | ·368 | ·315 | ·250 | ·176 | ·093 |
| 20 | ·509 | ·504 | ·489 | ·463 | ·428 | ·382 | ·326 | ·260 | ·183 | ·096 |
| 25 | ·527 | ·522 | ·506 | ·480 | ·443 | ·396 | ·338 | ·269 | ·190 | ·100 |
| 30 | ·545 | ·540 | ·524 | ·496 | ·458 | ·409 | ·350 | ·278 | ·196 | ·103 |
| 35 | ·564 | ·558 | ·541 | ·513 | ·474 | ·423 | ·361 | ·288 | ·203 | ·107 |
| 40 | ·582 | ·576 | ·559 | ·529 | ·489 | ·436 | ·373 | ·297 | ·209 | ·110 |
| 45 | ·600 | ·594 | ·576 | ·546 | ·504 | ·450 | ·384 | ·306 | ·216 | ·114 |
| 50 | ·618 | ·612 | ·594 | ·562 | ·519 | ·464 | ·396 | ·315 | ·222 | ·117 |
| 55 | ·636 | ·630 | ·611 | ·579 | ·535 | ·477 | ·408 | ·325 | ·229 | ·121 |
| 3 | ·654 | ·648 | ·629 | ·595 | ·550 | ·491 | ·419 | ·334 | ·235 | ·124 |
| 5 | ·673 | ·666 | ·646 | ·612 | ·565 | ·504 | ·431 | ·343 | ·242 | ·128 |
| 10 | ·691 | ·684 | ·664 | ·629 | ·581 | ·518 | ·443 | ·353 | ·249 | ·131 |
| 15 | ·709 | ·702 | ·681 | ·645 | ·596 | ·532 | ·454 | ·362 | ·255 | ·134 |
| 20 | ·727 | ·720 | ·699 | ·662 | ·611 | ·545 | ·466 | ·371 | ·262 | ·138 |
| 25 | ·745 | ·738 | ·716 | ·678 | ·627 | ·559 | ·478 | ·380 | ·268 | ·141 |
| 30 | ·764 | ·756 | ·734 | ·695 | ·642 | ·573 | ·489 | ·390 | ·275 | ·145 |
| 35 | ·782 | ·774 | ·751 | ·711 | ·657 | ·586 | ·501 | ·399 | ·281 | ·148 |
| 40 | ·800 | ·792 | ·769 | ·728 | ·673 | ·600 | ·512 | ·408 | ·288 | ·152 |
| 45 | ·818 | ·810 | ·786 | ·744 | ·688 | ·613 | ·524 | ·418 | ·294 | ·155 |
| 50 | ·836 | ·828 | ·804 | ·761 | ·703 | ·627 | ·536 | ·427 | ·301 | ·159 |
| 55 | ·854 | ·846 | ·821 | ·778 | ·718 | ·641 | ·547 | ·436 | ·308 | ·162 |
| 4 | ·873 | ·864 | ·839 | ·794 | ·734 | ·654 | ·559 | ·445 | ·314 | ·166 |
| 15 | ·927 | ·918 | ·891 | ·844 | ·780 | ·695 | ·594 | ·473 | ·334 | ·176 |
| 30 | ·981 | ·972 | ·944 | ·893 | ·825 | ·736 | ·629 | ·501 | ·354 | ·186 |
| 45 | 1·036 | 1·026 | ·996 | ·943 | ·871 | ·777 | ·664 | ·529 | ·373 | ·196 |
| 5 | 1·091 | 1·080 | 1·048 | ·993 | ·917 | ·818 | ·699 | ·557 | ·393 | ·207 |

*Ordinates for Laying Out Curves. Ordinates 5 feet apart. Chord 100 feet.*

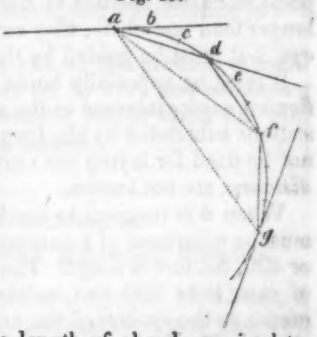
| Deflexion Angle in degrees and minutes. | | Distances of the Ordinates from the end of the 100 feet Chord. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Middle 50 feet. | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet. |
| | | Lengths of Ordinates in feet. | | | | | | | | | |
| ° | ′ | | | | | | | | | | |
| | 15 | 1·146 | 1·134 | 1·100 | 1·042 | ·963 | ·859 | ·734 | ·585 | ·413 | ·217 |
| | 30 | 1·200 | 1·188 | 1·153 | 1·092 | 1·009 | ·900 | ·769 | ·613 | ·432 | ·228 |
| | 45 | 1·255 | 1·242 | 1·205 | 1·141 | 1·055 | ·941 | ·804 | ·640 | ·452 | ·238 |
| 6 | | 1·309 | 1·296 | 1·258 | 1·191 | 1·100 | ·982 | ·839 | ·668 | ·472 | ·249 |
| | 15 | 1·364 | 1·350 | 1·310 | 1·240 | 1·146 | 1·023 | ·874 | ·696 | ·492 | ·259 |
| | 30 | 1·419 | 1·404 | 1·362 | 1·290 | 1·192 | 1·064 | ·909 | ·724 | ·511 | ·269 |
| | 45 | 1·473 | 1·458 | 1·415 | 1·339 | 1·238 | 1·105 | ·944 | ·752 | ·531 | ·280 |
| 7 | | 1·528 | 1·512 | 1·467 | 1·389 | 1·284 | 1·146 | ·979 | ·779 | ·551 | ·290 |
| | 15 | 1·582 | 1·566 | 1·520 | 1·438 | 1·330 | 1·187 | 1·014 | ·807 | ·570 | ·301 |
| | 30 | 1·637 | 1·620 | 1·572 | 1·488 | 1·375 | 1·228 | 1·048 | ·835 | ·590 | ·311 |
| | 45 | 1·692 | 1·674 | 1·624 | 1·537 | 1·421 | 1·269 | 1·083 | ·863 | ·610 | ·321 |
| 8 | | 1·746 | 1·728 | 1·677 | 1·587 | 1·467 | 1·310 | 1·118 | ·891 | ·629 | ·332 |
| | 15 | 1·801 | 1·782 | 1·729 | 1·636 | 1·513 | 1·351 | 1·153 | ·918 | ·649 | ·342 |
| | 30 | 1·855 | 1·836 | 1·782 | 1·686 | 1·559 | 1·392 | 1·188 | ·946 | ·669 | ·353 |
| | 45 | 1·910 | 1·890 | 1·834 | 1·735 | 1·605 | 1·433 | 1·223 | ·974 | ·689 | ·363 |
| 9 | | 1·965 | 1·944 | 1·886 | 1·785 | 1·651 | 1·474 | 1·258 | 1·002 | ·708 | ·373 |
| | 15 | 2·019 | 1·998 | 1·939 | 1·834 | 1·696 | 1·515 | 1·293 | 1·030 | ·728 | ·384 |
| | 30 | 2·074 | 2·052 | 1·991 | 1·884 | 1·742 | 1·556 | 1·328 | 1·057 | ·748 | ·394 |
| | 45 | 2·128 | 2·106 | 2·044 | 1·933 | 1·788 | 1·597 | 1·363 | 1·085 | ·767 | ·405 |
| 10 | | 2·183 | 2·161 | 2·096 | 1·987 | 1·834 | 1·637 | 1·398 | 1·114 | ·787 | ·415 |
| | 15 | 2·238 | 2·215 | 2·148 | 2·037 | 1·880 | 1·678 | 1.433 | 1·142 | ·807 | ·425 |
| | 30 | 2·292 | 2·269 | 2·201 | 2·087 | 1·926 | 1·719 | 1.468 | 1·170 | ·827 | ·436 |
| | 45 | 2·347 | 2·323 | 2·254 | 2·136 | 1·972 | 1·761 | 1.503 | 1·198 | ·846 | ·446 |
| 11 | | 2·401 | 2·377 | 2·306 | 2·186 | 2·018 | 1·802 | 1·538 | 1·226 | ·866 | ·457 |
| | 15 | 2·456 | 2·432 | 2·359 | 2·236 | 2·064 | 1·843 | 1·574 | 1·254 | ·886 | ·467 |
| | 30 | 2·511 | 2·486 | 2·411 | 2·286 | 2·110 | 1·884 | 1·609 | 1·282 | ·906 | ·478 |
| | 45 | 2·566 | 2·540 | 2·464 | 2·336 | 2·156 | 1·926 | 1·644 | 1·310 | ·926 | ·488 |
| 12 | | 2·620 | 2·594 | 2·516 | 2·386 | 2·203 | 1·967 | 1·680 | 1·339 | ·946 | ·499 |
| | 15 | 2·675 | 2·649 | 2·569 | 2·436 | 2·249 | 2·008 | 1·715 | 1·367 | ·966 | ·509 |
| | 30 | 2·730 | 2·703 | 2·621 | 2·485 | 2·295 | 2·049 | 1·750 | 1·395 | ·985 | ·520 |
| | 45 | 2·785 | 2·757 | 2·674 | 2·535 | 2·341 | 2·091 | 1·785 | 1.423 | 1·005 | ·530 |
| 13 | | 2·839 | 2·811 | 2.726 | 2·585 | 2·387 | 2·132 | 1·820 | 1·451 | 1·025 | ·541 |
| | 15 | 2·894 | 2·865 | 2.779 | 2·635 | 2·433 | 2·173 | 1·855 | 1·479 | 1·045 | ·551 |
| | 30 | 2·949 | 2·920 | 2.832 | 2·685 | 2·479 | 2·214 | 1·891 | 1·507 | 1·065 | ·562 |
| | 45 | 3.000 | 2·974 | 2.884 | 2·735 | 2·525 | 2·256 | 1·926 | 1·535 | 1·085 | ·572 |
| 14 | | 3·058 | 3·028 | 2.937 | 2·785 | 2·571 | 2·297 | 1·961 | 1·564 | 1·105 | ·583 |
| | 15 | 3·113 | 3·082 | 2·989 | 2·834 | 2·618 | 2·338 | 1.996 | 1·592 | 1·124 | ·593 |
| | 30 | 3·168 | 3·136 | 3·042 | 2·884 | 2·664 | 2·379 | 2.031 | 1·620 | 1·144 | ·604 |
| | 45 | 3·222 | 3·191 | 3·094 | 2·934 | 2·710 | 2·421 | 2·067 | 1·648 | 1·164 | ·614 |
| 15 | | 3·277 | 3·245 | 3·147 | 3·984 | 2·756 | 2·462 | 2·102 | 1·676 | 1·184 | ·625 |
| | 15 | 3·332 | 3·299 | 3·200 | 3·034 | 2·802 | 2·503 | 2·137 | 1·704 | 1·204 | ·635 |
| | 30 | 3·387 | 3·354 | 3·252 | 3·084 | 2·848 | 2·544 | 2·172 | 1·732 | 1·224 | ·646 |
| | 45 | 3·442 | 3·408 | 3·305 | 3·134 | 2·895 | 2·586 | 2·208 | 1.760 | 1·244 | ·656 |
| 16 | | 3·496 | 3·462 | 3·358 | 3·184 | 2·941 | 2·627 | 2·243 | 1·789 | 1·264 | ·667 |
| | 30 | 3·606 | 3·571 | 3·463 | 3·284 | 3.033 | 2·710 | 2·314 | 1·845 | 1·304 | ·688 |
| 17 | | 3.716 | 3·680 | 3·569 | 3·384 | 3.125 | 2·792 | 2·384 | 1·902 | 1·344 | ·709 |
| | 30 | 3·826 | 3·788 | 3·674 | 3·484 | 3·218 | 2·875 | 2·455 | 1·958 | 1·384 | ·730 |
| 18 | | 3·935 | 3·897 | 3·779 | 3·584 | 3·310 | 2·958 | 2·525 | 2·014 | 1·424 | ·751 |
| | 30 | 4·045 | 4·006 | 3·885 | 3·684 | 3·403 | 3·040 | 2·596 | 2·071 | 1·464 | ·772 |
| 19 | | 4·155 | 4·115 | 3·990 | 3·784 | 3·495 | 3·123 | 2·666 | 2·127 | 1·504 | ·793 |
| | 30 | 4·265 | 4·223 | 4·096 | 3·884 | 3·588 | 3·205 | 2·737 | 2·184 | 1·544 | ·814 |
| 20 | | 4·375 | 4·332 | 4·201 | 3·984 | 3.680 | 3·288 | 2·808 | 2.240 | 1·583 | ·836 |

*Ordinates for Laying Out Curves. Ordinates 5 feet apart. Chord 100 feet.*

| Deflexion Angle in degrees and minutes. | Distances of the Ordinates from the end of the 100 feet Chord. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Middle 50 feet. | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet. |
| | Lengths of Ordinates in feet. | | | | | | | | | |
| ° ′ | | | | | | | | | | |
| 21 | 4·595 | 4·549 | 4·412 | 4·184 | 3·864 | 3.454 | 2·950 | 2·853 | 1·663 | ·879 |
| 22 | 4·815 | 4·768 | 4·624 | 4·386 | 4·050 | 3.620 | 3·093 | 2·467 | 1·744 | ·922 |
| 23 | 5·035 | 4·986 | 4·836 | 4·587 | 4·237 | 3·786 | 3·236 | 2·581 | 1·824 | ·965 |
| 24 | 5·255 | 5·204 | 5·048 | 4·789 | 4·423 | 3·952 | 3·379 | 2·695 | 1·905 | 1·008 |
| 25 | 5·476 | 5·422 | 5·260 | 4·989 | 4·609 | 4·119 | 3·522 | 2·809 | 1·986 | 1·051 |
| 26 | 5·697 | 5·642 | 5·473 | 5·192 | 4·798 | 4·286 | 3·665 | 2·924 | 2·068 | 1·094 |
| 27 | 5·918 | 5·860 | 5·685 | 5·393 | 4·984 | 4·454 | 3·808 | 3·039 | 2·150 | 1·137 |
| 28 | 6·139 | 6·079 | 5·898 | 5·595 | 5·171 | 4·622 | 3·952 | 3·154 | 2·232 | 1·181 |
| 29 | 6·361 | 6·298 | 6·110 | 5·796 | 5·357 | 4·790 | 4·095 | 3·269 | 2·314 | 1·224 |
| 30 | 6·582 | 6·517 | 6·323 | 5·999 | 5·544 | 4·958 | 4·239 | 3·385 | 2·396 | 1·268 |
| 31 | 6·804 | 6·737 | 6·537 | 6·202 | 5·733 | 5·127 | 4·384 | 3·502 | 2·481 | 1·312 |
| 32 | 7·027 | 6·957 | 6·751 | 6·406 | 5·922 | 5·297 | 4·530 | 3·619 | 2·565 | 1·356 |
| 33 | 7·249 | 7·178 | 6·965 | 6·609 | 6·111 | 5·467 | 4·676 | 3·737 | 2·649 | 1·401 |
| 34 | 7·472 | 7·398 | 7·179 | 6·813 | 6·300 | 5·637 | 4·822 | 3·854 | 2·733 | 1·445 |
| 35 | 7·694 | 7·619 | 7·393 | 7·017 | 6·489 | 5·807 | 4·968 | 3·972 | 2·817 | 1·490 |
| 36 | 7·918 | 7·841 | 7·609 | 7·222 | 6·679 | 5·978 | 5·115 | 4·090 | 2·901 | 1·535 |
| 37 | 8·143 | 8·063 | 7·825 | 7·427 | 6·870 | 6·149 | 5·262 | 4·209 | 2·985 | 1·581 |
| 38 | 8·367 | 8·286 | 8·041 | 7·633 | 7·060 | 6·320 | 5·410 | 4·327 | 3·069 | 1·626 |
| 39 | 8·592 | 8·508 | 8·257 | 7·838 | 7·251 | 6·491 | 5·557 | 4·446 | 3·153 | 1·672 |
| 40 | 8·816 | 8·731 | 8·474 | 8·044 | 7·442 | 6·663 | 5·705 | 4·565 | 3·238 | 1·718 |

It is sometimes convenient in preliminary locations, to lay off curves by chords longer than 100 feet. For instance, in fig. 19, instead of running from *a* by chords *a b*, *b c*, *c d*, &c., of but 100 feet, points *d f g*, &c., may be obtained with less trouble by using three times the tangential or deflexion angles of the table, (as the case may be,) and employing chords *a d*, *d f*, *f g*, &c., *nearly* three times as long as the chords *a b*, *b c*, &c.; or if *a d*, *d f*, *f g*, be either 2 or 4 stations apart, then 2 or 4 times the tangential and deflexion angles would be used; and chords nearly 2 or 4 times 100 feet in length.

Fig. 19.




The following table contains the *precise* length of chord required to subtend respectively 1, 2, 3, or 4 stations. It is seldom desirable to exceed the latter limit.

*Table of Chords.*

| Radius in feet. | Angle of Deflexion | Length of Chord in feet required to subtend. | | | | Radius in feet. | Angle of Deflexion | Length of Chord in feet required to subtend. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 sta'n | 2 sta'n | 3 sta'n | 4 sta'n | | | 1 sta'n | 2 sta'n | 3 sta'n | 4 sta'n |
| 5730·0 | 1° | 100 | 200·0 | 300·0 | 400·0 | 995·4 | 6° | 100 | 199·7 | 298·8 | 397·3 |
| 4584·0 | ¼ | 100 | 200·0 | 300·0 | 399·9 | 917·0 | ¼ | 100 | 199·7 | 298·7 | 397·0 |
| 3820·0 | ½ | 100 | 200·0 | 300·0 | 399.9 | 882·0 | ½ | 100 | 199·7 | 298·6 | 396·7 |
| 3274·0 | ¾ | 100 | 200·0 | 300·0 | 399·8 | 849·3 | ¾ | 100 | 199·6 | 298·5 | 396·5 |
| 3865·0 | 2° | 100 | 200·0 | 299·9 | 399·7 | 819·0 | 7° | 100 | 199·6 | 298·4 | 396·2 |
| 2547·0 | ¼ | 100 | 200·0 | 299·9 | 399·6 | 790·8 | ¼ | 100 | 199·6 | 298·3 | 396·0 |
| 2292·0 | ½ | 100 | 200·0 | 299·8 | 399·5 | 764·5 | ½ | 100 | 199·6 | 298·2 | 395·7 |
| 2084·0 | ¾ | 100 | 200·0 | 299·8 | 399·4 | 739·9 | ¾ | 100 | 199·6 | 298·1 | 395·4 |
| 1910·0 | 3° | 100 | 200·0 | 299·7 | 399·3 | 716·8 | 8° | 100 | 199·6 | 298·0 | 395·1 |
| 1763·0 | ¼ | 100 | 200·0 | 299·7 | 399·2 | 695·1 | ¼ | 100 | 199·5 | 297·9 | 394·8 |
| 1637·0 | ½ | 100 | 200·0 | 299·6 | 399·1 | 674·6 | ½ | 100 | 199·5 | 297·8 | 394·5 |
| 1528·0 | ¾ | 100 | 200·0 | 299·6 | 399·0 | 655·5 | ¾ | 100 | 199·4 | 297·7 | 394·3 |
| 1433·0 | 4° | 100 | 199·9 | 299·6 | 398·9 | 637·3 | 9° | 100 | 199·4 | 297·5 | 394·1 |
| 1348·0 | ¼ | 100 | 199·9 | 299·5 | 398·7 | 620·2 | ¼ | 100 | 199·4 | 297·4 | 393·7 |
| 1274·0 | ½ | 100 | 199·9 | 299·4 | 398·5 | 603·8 | ½ | 100 | 199·3 | 297·3 | 393·2 |
| 1207·0 | ¾ | 100 | 199·9 | 299·3 | 398·3 | 588·4 | ¾ | 100 | 199·2 | 297·2 | 392·8 |
| 1146·0 | 5° | 100 | 199·9 | 299·2 | 398·0 | 573·7 | 10° | 100 | 199·2 | 297·0 | 392·4 |
| 1092·0 | ¼ | 100 | 199·8 | 299·1 | 397·8 | For radii less than 573·7 feet, it is never required to use longer chords than 100 feet. | | | | | |
| 1042·0 | ½ | 100 | 199·8 | 299·0 | 397·6 | | | | | | |
| 996·8 | ¾ | 100 | 199·7 | 298·9 | 397·5 | | | | | | |

When this method of laying out curves by long chords is used, the instrument should be moved to each successive point after it is determined, in order to fix the next one, instead of attempting to obtain more than one point from one position of the instrument; because when the chords are longer than one chain, they cannot be measured in the right direction by eye, but must be guided by the instrument.

It must be especially borne in mind, that only the tangential and deflexion *angles* increase in the same proportion as the number of 100 feet stations subtended by the long chord. Therefore, *these* long chords cannot be used for laying out curves *by eye*, as their tangential and deflexion *distances* are not known.

When it is required to use long chords for turning a curve *by eye*, they must be composed of a number of *whole chains*, being made, say 200, 300, or 400, &c. feet in length The tangential and deflexion distances of curves of more than 500 feet radius, may then be assumed in practice, to increase as the *squares* of the number of chains in the length of the long chord. For instance, to lay off a 5° curve by chords of 200, 300, or 400 feet in length, the tangential and deflexion distances of the table must be multiplied by 4, 9, or 16, as the case may be. In this case the tangential and deflexion *angles* are unknown.

This is not mathematically correct, but will answer in practice for the curves on a canal or common road, where great nicety is not needed.

The only proper instrument for running lines of survey, is the *transit* furnished with a compass, and with a revolving telescope. The deflexions being measured in *angles*, serve as a check to the numerous sources of error to which the compass is liable, arising from local attraction, electrical action in the glass cover, diurnal variation, &c., &c. Besides,

when the compass alone is used, it is necessary to test every course or bearing from each end of each station; and this involves much loss of time.

The following is a good form of field book for the transit and compass combined:

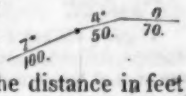
| Station. | Distance. | Total Distance. | Course. | Deflexion in Degrees. | Remarks. |
|---|---|---|---|---|---|

In every locating party, there should be one person whose duty is to take and record the transverse slopes of the ground at each station. His observations will usually extend to from 50 feet to 100 yards on each side of the centre stakes; depending on a variety of circumstances of locality which cannot be alluded to here. In preliminary locations these slopes need not be taken with very great nicety, as they will be used chiefly for ascertaining approximately the amount of excavation and embankment, by a rapid process, which will be described in a paper on that subject in the next number of the Journal.

After the final location is made, the slopes should be taken again with great care, to quarters of a degree, but need not extend beyond the width actually occupied by the road. Their use in this second operation, will be for determining the cubic contents with more precision than before for final estimates, and also for obtaining the positions of the *side-stakes*.

Should the duty of *recording* these slopes devolve upon the compass man, (which it should not,) it will be necessary to add another column to his field book, after that containing the deflexions. In this column he will insert the slopes, thus, (Fig. 20,) the circle representing the centre stake. The degrees of slope are written above the lines; and the distance in feet to which they extend, below.

Fig. 20.




The slopes are taken by laying a long rod on the ground, at *right angles to the line of survey*, as nearly as may be, by eye; and measuring the angles by means of a small *slope instrument* placed upon the rod. These are made by most of our instrument makers.

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Translated for the Journal of the Franklin Institute.

## *Apparatus of* M. Groetars *for Measuring Inaccessible Distances.*

The apparatus for measuring inaccessible distances of M. Groetars, who is a captain of the Belgian engineers, is founded upon the well known theory, that if from the right angle of any right angled triangle, a perpendicular be let fall upon the hypothenuse, this perpendicular is a mean proportional between the segments of the hypothenuse; whence it follows, that if the length of this perpendicular and one of the segments be known, a simple arithmetical calculation will give the other segment. Suppose then such a triangle traced on the ground; the inaccessible point whose distance is to be known being at one of the angles, and two observers, the first at the right angle, the other at the foot of the perpendicular, which is measured by a cord of constant length stretched between them, each observer being furnished with a reflecting quadrant fixed so as to give a right angle. Each observer takes the inaccessible point for

one object. The observer at the foot of the perpendicular will have for his second object the image of the observer stationed at the right angle, while the target is slid along the prolongation of the line from the foot of the perpendicular to the inaccessible point, until it forms its image in the instrument of the observer at the right angle; the distance of this target from the foot of the perpendicular then gives one segment of the hypothenuse, the other being the distance sought.—*Bull. de la Société d'Encouragement pour l'Industrie Nationale, Janvier*, 1851.

## AMERICAN PATENTS.

*List of American Patents which issued from April 22, to May 13, 1851, (inclusive,) with Exemplifications by* CHARLES M. KELLER, *late Chief Examiner of Patents in the U. S. Patent Office.*

46. For an *Improvement in Means of Renovating and Correcting Sight;* Jonathan Ball, City of New York, April 22.

*Claim.*—"What I claim as my invention, is the cups and caps, to produce a pressure upon the periphery, in case of old age, or front of the eye, in case of near sight, which will increase or diminish its convexity, as the nature of the case may require, with their application as set forth in the accompanying specifiations and drawings, using for that purpose any of the materials named in the above specifications."

47. For an *Improvement in Cooking Stoves;* Charles W. Grannis, Gowanda, New York, April 22.

*Claim.*—"What I claim as my invention, is, 1st, the arrangement of the flues which conduct the heated air to the space under the oven bottom, from which it is discharged into the oven at the corners thereof, and without any enlargement to permit the expansion of the air before it reaches the oven, as described, when this is combined with the arrangement of fire flues on each side thereof, as described, whereby the air passing to the oven, is heated along the whole distance of its passage, by the products of combustion from the fire place as described.

"2d, I also claim as my invention, the heating of the air in its passage through the back hot air chambers, by combining with such air chambers and the main fire flues, the branch of fire flues, which pass back of the said air chambers, substantially as described."

48. For an *Improvement in Machines for Gutta Percha Tubing and Covering Wire;* James Reynolds, City of New York, April 22.

"The nature of my invention refers to the formation of tubes of any plastic material, with or without wires throughout them, and consists in reducing to a fluid or partly fluid state, by the application of heat, a band or strip of the plastic substance, which is fed into the stomach of the machine by friction rollers, and delivered through a suitable mould tube, that, together with its mandril, or wire guide, are situated at right angles or other similar position with relation to the feed rollers."

*Claim.*—"What I claim as my invention, is the use for the purposes specified of feed rollers C C, in combination with the stomach G G, having a lip or mouth *h*, arranged and operating substantially as shown and described."

49. For an *Improvement in Machines for Stretching Leather;* Bradford Rowe, Albany, New York, April 22.

*Claim.*—"I claim the method or device of stretching leather, especially for belting, by the use of apparatus so arranged, that after a piece of leather has received, by an equable strain applied to its ends, for their whole width, the proper stretch that the material can bear on or along one edge thereof, if it be found that the other edge and parts intermedate between it and the first edge, (from the difference in quality of fibre,) has not received its proper tension, the further stretching of the first side shall be stopped, whilst,

by the application of the mechanical stress, at the other edge of the leather, it and the parts between it and the first side, shall be duly stretched, substantially in the manner set forth in this specification.

"I claim the holding board as essential in all leather stretching apparatus, where it can be applied, in keeping the material, whilst being stretched, from contracting in width and becoming defective thereby.

"I claim the holding board with its clamps and wedges, in combination with the apparatus for stretching, for the uses and purposes substantially as set forth in the above specification."

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50. For an *Improvement in Clogs or Pattens;* Charles W. Stearns, Springfield, Massachusetts, April 22.

*Claim.*—"What I claim, therefore, as my invention, is the application of an elastic loop, or strap, attached to the sole piece, and going around the heel, substantially as in the manner above described."

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51. For an *Improvement in Machines for Stretching Leather;* William Strevell and Daniel Brown, Albany, New York, April 22.

"The object of this improvement is, whenever material (as belting leather) whose fibres possess different tensile properties in the direction of their length, are subjected to the operation of stretching, the more yielding part on one side of the centre of the rod may receive the greater stretch, by the drawing down of the side of the clamp, which is on the other side of the centre, by the less yielding parts of the material."

*Claim.*—"We claim the construction of the stretching apparatus, by connecting the free rod to the clamp, by entering the end or tenon of the rod into a mortice with angular sides, and securing them together by a pivot pin, substantially as set forth in this specification."

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52. For an *Improved Apparatus for Rolling Tapered Metallic Rods;* William Clay, Clifton Lodge, England, April 22. Patented in England, December 16, 1848.

"My invention consists in the adaptation to rolling machinery, of pistons bearing against confined columns of water, or other non-elastic fluid, the ends of the piston rods mantaining or affording the means of keeping the bearings of the rollers from shifting their positions, excepting as the columns of water are allowed to relax their resistance, by a slow and gradual escape of the fluid from the cylinder or chamber through an adjustable valve."

*Claim.*—"What I claim as my invention, is permitting the rollers to recede from each other by means of the hydraulic apparatus, constructed and arranged substantially as described.

"And secondly, the adjustable screw *k*, fig. 1 and 2, in conjunction with the apparatus claimed above, whereby bars of metal are enabled to be rolled tapered for a portion of their length, and parallel for the remaining part thereof."

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53. For an *Improvement in Saw Mills;* Lemuel Hedge, Assignor to George W. Hedge, Brooklyn, New York, April 22.

"The nature of my invention consists in so arranging and combining the machinery, as to prevent the necessity of straightening and straining longitudinally any other part of the saw, excepting that portion of it which is at the time at work."

*Claim.*—"What I claim as my invention, is the method substantially as herein described, of driving belt saws by the friction surface of two cylindrical pulleys or drums, which gripe the saw plate below the wood which is being cut, but at some part of its tangent line, so that the strain to which it must be subjected in cutting, to keep it in the line of the tangent, shall not be at any part of its curved path; but this I only claim, in combination with straining rollers, which gripe the saw above the lumber on which it acts, the said rollers being controlled by a brake, or the equivalent thereof, substantially as described, whereby the saw during its action is kept in a strained condition along its entire line of action, that it may cut in a straight line, and to avoid its being under tension where the fiexions take place along the curved portions of its track, as specified.

"I also claim in combination with the mode herein specified, of driving a belt saw by means of cylindrical rollers or pulleys, the employment of a belt passing around the outer

one of the said driving rollers, and applied to the outer surface of the saw, when it passes around the lower deflecting or guide pulley, substantially as herein described, by means of which the saw is bent, by the pressure of the belt applied to its outer surface, instead of being communicated through the metal itself—thus avoiding, in a great measure, the tendency to break the metal.

"And finally, I claim in combination with the mode, substantially as herein described, of driving a belt saw, the employment of fenders or scrapers interposed between the driving rollers and the wood to be sawed, and placed each side of the saw, as described, to catch the sawdust, and conduct it away from the bight of the driving rollers or the saw, and thus avoid clogging."

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54. For an *Improvement in Coffee Roasters;* Edward Whiteley, Boston, Massachusetts, April 22.

*Claim.*—"What I claim is the combining or arrangement of the fire place, or chamber of combustion, the roasting cylinder and its surrounding chamber, substantially in the manner as above described, and as represented in the drawings.

"Also the arrangement of the flue of the fire chamber, with respect to the latter and the enclosing chamber of the roaster, the said arrangement of the said flue consisting in carrying it over and in contact with the top of the said enclosing chamber, as specified.

"I also claim the arrangement of the proving tube, within the hollow journals and central part of the roaster; not meaning to claim the device termed the proving tube, but simply the arrangement as specified."

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55. For an *Improvement in Straw Cutters;* Tazwell F. Wingo, M'Lemoresville, Tennessee, April 22.

*Claim.*—"Having thus fully described my invention, what I claim therein as new, is the manner herein described of arranging one or more cutters on the periphery of a vertical wheel, at such angle with, and so extending over the face of said wheel, as will give a "drawing cut" through the straw or other material to be cut, and at the same time catch and carry the material as it falls, to the opposite side of the wheel from where it is cut, thus removing the cut material out of the way of the feeding box and uncut material, as fully set forth and shown."

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56. For an *Improvement in Car Seats;* R. Stilwell, City of New York, and E. L. Brundage, Troy, New York, April 22.

*Claim.*—"Having thus described the nature of our invention, what we claim as new, is the mode herein described, of reversing the back of car seats, from one side of the seat to the other, without turning them over, by means of arms constructed and arranged as set forth, by which any desired height of back is obtained, as described.

"2d, We claim the manner herein described, of reversing the concave back on a movable frame, in combination with the side locking projections, as described."

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57. For an *Improved Lock and Key;* James R. Bugbee, Boston, Assignor to James R. Bugbee and Enoch Robinson, Somerville, Massachusetts, April 22.

*Claim.*—"What I claim as my invention, is the wedged or cam key I, and the separate bitt or secondary wedged or cam key H, in combination with the vibrating block F, the key recess, and the tumbler elevators; the whole being constructed, arranged, and operating substantially as herein before specified."

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58. For an *Improvement in Smut Machines;* Jehu Hollingsworth, Zanesville, Ohio, April 22.

*Claim.*—"Having thus fully described my invention, what I claim therein as new, is the manner herein described of scouring and freeing wheat of smut and other impurities, by throwing up the grain on to the inclined face of a chimney, fitted to an opening along the top of the concave in combination with the inclined aprons U, for transferring the grain from end to end of the cylinder, that it may be discharged, as set forth."

59. For an *Improved Compound Metallic Door for Vaults, Safes, etc.;* Ira L. Cady, Newport, New York, April 29.

"The nature of my invention consists in making an iron door, wall, or chest, with common iron, and white, hard, cast iron, chilled, which makes it so hard it cannot be drilled or cut."

*Claim.*—"What I claim as my invention, is a door or wall for a vault or safe, made by securing to each other at a certain distance apart, two plates of sheet metal, provided with a rim or curb, and filling the vacant space between them with immalleable cast iron, poured in while melted, substantially in the manner herein described."

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60. For an *Improvement in Winnowing Machines;* Oliver Etnier, Shirley Township, Pennsylvania, April 29.

"The object of my improvements is to effect a more perfect separation of the wheat from the pieces of straw, chaff, cheat, small grains, dirt, &c., than can be performed by machines of the ordinary construction, unless the grain is run through them two or more times."

*Claim.*—"Having thus fully described my improved wheat fan, what I claim as new therein, is, 1st, placing the screw *d* in an inclined position above the fan, and extending the whole length of the machine, by which the wheat is thoroughly sifted before being acted upon by the blast, in combination with the direction of the blast at right angles to the screw, as above set forth."

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61. For an *Improvement in Spring Saddles;* Joseph C. Smith, Stoughstown, Pennsylvania, April 29.

"My invention consists in mounting upon the saddle-tree, a series of spring plates, which cross it transversely, and bridge the opening between the side pieces; these bridge springs being all connected by a spring plate, which extends longitudinally from the pommel towards the cantle, and is connected with the former by a spring, which allows it to yield as the bridge springs are depressed by the weight of the rider."

*Claim.*—"Having thus described my bridge-spring saddle-tree, what I claim therein as new, is the pommel spring, in combination with the seat springs, substantially as herein set forth.

"I also claim the method of suspending the stirrups, by connecting them with the same springs which support the seat, whereby the elevation and depression of the one is simultaneous with the elevation and depression of the other."

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62. For an *Improvement in Apparatus for Giving Ease to the Arm in Writing;* Joseph G. Goshon, Shirleysburgh, Pennsylvania, and William H. Towers, Bucyrus, Ohio, April 29.

*Claim.*—"Having thus described our invention and improvement, and shown the application of the same to the arm of the penman; what we claim as our invention, is constructing an arm supporter or rest, so formed and shaped as to fit the arm below the elbow joint, and serve as an elastic or flexible support or rest, on which the arm of the penman is supported and balanced, and permitted to move or turn with the motion of the arm, with the utmost freedom and ease to the writer, by which all numbness, contraction of the muscles of the fingers, and crampness or stiffness of the arm, is effectually prevented, and the arm rendered free in its movement, and under the complete control of the writer, as fully described and represented."

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63. For an *Improvement in Machinery for Making Matches;* Ira H. Smith, Wolcott, Connecticut, April 29.

*Claim.*—"What I claim as my invention, is, 1st, the mode of feeding in the plates of wood, by means of the feeding apron, with its cleats, spring pulley F, and rollers *g g*.

"2d, The mode of separating and dipping the splints, by means of the grooved cylinder C, cutter *n*, endless bands B, and revolving wheels *e e*."

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64. For an *Improved Horse Shoe Machine;* Robert G. Babcock, New London, Connecticut, April 29; anté dated February 24, 1851.

"The nature of my invention consists in bending, drawing, and chamfering horse shoes,

at the same operation; the machine being so adjustable as to be adapted for making larger or smaller shoes, and the draught of the shoe, from toe to heel, be drawn out by a pattern, to any form desired."

*Claim.*—"Having thus fully described my invention, what I claim therein as new, is in combination with a rotating, traveling draw roller, adjustable pattern, and clamping tool for forming the shoe, the gauge plate for holding up the roller, so as to allow it to return over the shoe thus formed, and smooth down the feathered edges raised by the chamfering tool, as herein described and represented."

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65. For an *Improvement in Bats for Felting;* Leander W. Boynton, South Coventry, Connecticut, April 29.

*Claim.*—"What I claim as my invention, is preparing the web for felt fabrics, by the introduction of layers of flocks between or upon the layers of wool, without passing the flock through the carding machine, but by preparing it in a separate machine, and introducing it immediately from that machine on to the web of wool, while it is passing from the carding machine, in the manner substantially as herein described.

"And I also claim as my invention, the combination of the endless apron K, which feeds the flock to the cylindrical brushes, with a series of cylindrical brushes, by which the flock is taken up from the inner extremity of the endless apron, and (passing through the series) is prepared and sent down through the spout or conductor A, and deposited on the web of wool, (as before described,) when the same is constructed and combined substantially as herein described."

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66. For an *Improvement in Splint Machines;* Lewis L. Gilliland, Dayton, Ohio, April 29.

*Claim.*—"What I claim as my invention, is a cutter wheel constructed substantially as herein set forth, to split, point, and gauge the size of match splints, in combination with the method of preventing the splitting knives from cutting across the grain of the wood, by supporting the block upon a stock, which is constructed to turn as herein set forth, to prevent the grain of the wood, where the splitting knife is acting in line with the plane in which the knives revolve."

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67. For a *Flexible Hose or Float for Supporting Vessels;* William Mt. Storm, City of New York, April 29.

*Claim.*—"Having thus fully described my invention, that which I claim is as follows: 1st, I claim a plan of supporting a vessel, in whole or part, upon or by means of a flexible, movable, endless hose, or "air float," or on an endless movable chain of flexible buoyant compartments, for the purposes set forth.

"2d, I claim making my flexible hose "air float," or its equivalent, collapsible for the purposes herein before mentioned.

"Not limiting myself in or by these claims, to any particular forms or arrangement of the buoys or "floats," &c., so long as the peculiar features of my invention as described and claimed are substantially fulfilled."

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### Re-issues for April, 1851.

1. For an *Improvement in Machinery for Doubling, Twisting, and Reeling Thread;* Frank Cheney, Manchester, Connecticut; patented October 9, 1847, re-issued April 29, 1851.

*Claim.*—"What I claim as my invention, is the above described combination of doubling, twisting, and reeling mechanism, or elements constructed, applied, and operating together, substantially as herein described; whereby, I am able to double, twist, and reel each thread by the same machine, substantially in the manner as herein before specified."

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### Designs for April, 1851.

1. For a *Design for Parlor Grates;* Winslow Ames, Nashua, New Hampshire, Assignor to Hartshorn and Ames, Boston, Massachusetts, April 1.

*Claim.*—"What I claim, is the new and ornamental design for the top plate, front plate, the base plate, and the blower, as represented in the drawings."

2. For a *Design for Air-Tight Stoves;* N. P. Richardson, Portland, Maine, April 1.

*Claim.*—"What I claim as my invention, is the ornamental design of the air-tight stove, substantially as exhibited in the drawings, and as above described."

3. For a *Design for Air-Tight Stoves;* Frederick Shultz, Philadelphia, Pennsylvania, April 1.

*Claim.*—"What I claim as my invention, is the design for stoves, substantially as herein set forth and represented in the accompanying drawings."

4. For a *Design for Stoves;* Seth Williams, Jr., Nashua, New Hampshire, Assignor to Williams Bird, & Co., North Chelmsford, Massachusetts, April 8.

*Claim.*—"I claim as my invention or production, the ornamental design, essentially as described and represented in the drawings."

5. For a *Design for Stoves;* Samuel W. Gibbs, Albany, Assignor to Jagger, Treadwell, and Perry, Albany, New York, April 8.

*Claim.*—"What I claim as my productian, is the combination and arrangement of ornamental figures and forms represented in the accompanying drawings, forming together an ornamental design for a cooking stove."

6. For a *Design for Cooking Stoves;* Dutee Arnold, Providence, Rhode Island, April 15

*Claim.*—"What I claim as my invention or production, is the design composed of the several ornamental mouldings and configurations herein above described and represented in the drawings, for the front, side, and back plates of a cooking stove."

7. For a *Design for Cooking Stoves;* John Abendroth, Port Chester, New York, April 15

*Claim.*—"What I claim as my invention, is the design, configuration and arrangement of the ornaments on the several parts of the cooking stove, as herein represented and described."

8. For a *Design for Bust of Jenny Lind;* Thomas Ball, Boston, Massachusetts, Ap'l 29

*Claim.*—"What I claim, is the design of a bust of Jenny Lind, of the cabinet size, as represented in the drawings above referred to."

## MAY.

1. For an *Improved Lock and Key;* Linus Yale, Jr., Newport, New York, May 6.

*Claim.*—"What I claim as my invention, is, 1st, the self-detaching and attaching key for the purpose and object described.

"2d, In combination with said key, I claim a powder proof key hole, consisting of two or more parts, so constructed that the outer part is turned by the key; while, at the same time, the inner parts, with the pod or pods of the key enclosed, are disconnected and moved entirely away from the outer, the same movement causing solid metal to occupy the space left, and thus to effectually bar an entrance of any kind to the lock, when its parts are in a position possible to be unlocked."

2. For an *Improvement in Meat Cutting Machines;* Thomas Vanderslice, Valley Forge Pennsylvania, May 6.

"The principal features of this invention, consist in an arrangement for adjusting the positions of the several rotary cutters, so as to keep the edges thereof in contact with the periphery of the cylindrical chamber, within which they revolve."

*Claim.*—"What I claim as my invention, is the herein described mode of adjusting the cutters J, by means of the adjusting plates K, as described."

3. For an *Exploding Harpoon;* Charles Burt, Belfast, Maine, May 6.

*Claim.*—"I do not claim the invention of the harpoon as ordinarily made, but what I do claim as my invention, is, 1st, the interior of the harpoon made as a pistol barrel, with percussion lock, protected from water, or outward accident, and the trigger of which can be actuated by means of a pull on the line, and the resistance of the flesh, substantially as described.

"2d, I claim the making the point of the harpoon, the projectile which is shot into the whale, in the manner and for the purposes substantially as described.

"3d, I claim the arrangement of the trigger in the shank under the barb, in the mode described, preventing the explosion of the charge, till the line is drawn by the whale or the harpooner."

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4. For an *Improvement in Hand Logs;* John R. St. John, City of New York, Assignor to James Renwick, George F. Barnard, and Edward B. St. John, May 6.

*Claim.*—"I therefore claim as new and of my own invention, 1st, the arrangement of the log glass, F, lever, *g*, pinion, *e*, and wheel, *f*, whereby the motion given to the clock work by the reel, G, is communicated to the index 9, during a definite period of time, determined by turning the log glass on or off the lever, *g*, the parts being so proportioned and the dial so divided that the index, moving while the sand is running in the log glass, F, shows the rate of speed at which the vessel is moving per hour of time, during fourteen seconds or any other known space of time; the parts being arranged and operating substantially as described, or in a manner equivalent, to produce the same results by like means.

"2d, The application of a parachute, K, to the purpose of a "*log ship*," and the combination therewith of the cylindrical wedge, *m*, or its equivalent, to enter between the tubes, *k* and *n*, to keep the "*log ship*," K, spread, when in the water, and disengaged when hauled on to "*fetch home*," so that the log ship closes and turns end for end, in the water, and is easily hauled on board; said log ship being used with the reel and registering parts herein described and shown, or with any other means of supplying and determining the amount of line run out, during a known period of time, substantially as described and shown."

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5. For an *Improvement in the Manufacture of India Rubber;* Nelson Goodyear, City of New York, May 6.

"The nature of my invention consists in so compounding caoutchouc with other substances, that the composition thus formed, when subjected to the heating or curing process, described in the Patent of Charles Goodyear, dated June 15th, 1844, and in the reissue of said Patent, dated December 25, 1849, will form a hard, stiff substance, hitherto unknown."

*Claim.*—"I do not claim the heating or curing process, as it is termed, that having been patented by Charles Goodyear. What I do claim as my invention, is the combining of India rubber and sulphur, either with or without shellac, for making a hard and inflexible substance, hitherto unknown, substantially as herein set forth."

"And I also claim the combining of India rubber, sulphur and magnesia, or lime, or a carbonate, or a sulphate of magnesia, or of lime, either with or without shellac, for making a hard and inflexible substance, hitherto unknown, substantially as herein set forth."

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6. For an *Improvement in Bedstead Fastenings;* James R. Kain and Spencer Lewis, Tiffin, Ohio, May 6.

*Claim.*—"Having thus described our improvements in the beadstead fastenings, what we claim therein as new, is providing the upper section or part, B, of the cylindrical box with a triangular and two parallel wedge-shaped wings, D, E, E, made sharp, and projecting from its periphery in such a manner, that the triangular projection, D, shall open a groove or way in the post, which shall be closed by the entrance of the parallel wedge-shaped wings, E, E, which follow as the section, B, is driven into the post, and thus crowd the wood in front of the shoulder (*a*) of the triangular projection D, and form a complete lock thereto, as described.

"We also claim dividing the cylindrical box longitudinally into two equal parts or sections, B, F, the line of division inclining upward at an angle of about 10 degrees from a horizontal plane, by which the edges of the upper section B, are made to serve the purpose of wedges for forcing the teeth of the lower section F, into the post, and holding it securely, as described."

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7. For an *Improved Spark Arrester;* James A. Cutting, Philadelphia, Pennsylvania, May 6.

*Claim.*—"Having thus fully described my invention, what I claim therein as new, is,

1st, the air flues F in the lower part of the diaphragm O, constructed in the manner and for the purposes herein described.

"2d, I claim the pipes or conductors, H, in combination with the air chambers, I and B, arranged substantially as herein described.

"3d, I claim the combination and arrangement of the air flues F, with the air chamber B, reverberating cone C, inclined and curved flues D, for the purpose and in the manner herein fully set forth and described."

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8. For an *Improvement in Pumps;* Nelson Newman, Cincinnati, Ohio, May 6.

*Claim.*—"What I claim as my invention, is the combination and arrangement of the valve chest, water passage, pump cylinder, and air vessel, as herein described, so that the whole can be cast in a single piece, and the valves and suction pipe supported and secured in place by another piece, also cast in the form herein described, whereby the cost of making the pump and its liability to get out of order are both lessened, without impairing its efficiency or rendering it more difficult to repair."

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9 For an *Improvement in Lime Kilns;* Richard E. Schroeder, Rochester, New York, May 6.

*Claim.*—"Having thus fully described the construction and operation of my improved lime kiln, what I claim therein as new, is the flues *d*, *d*, encircling the cupola, and provided with apertures or flues, *e*, *e*, *e*, *e*, *e*, for admitting the heat and flame to the action upon the limestone, from various points, substantially as described, in combination with the air chamber, *k*, encircling the cupola as described; and I claim also, the aperture, *p*, and passage therefrom, for saving the heat arising from the manufactured lime, while being removed; all operating conjointly, in the manner and for the purpose herein fully set forth."

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10. For an *Improved Process for the Artificial Production of Ice;* John Gorrie, New Orleans, Louisiana, May 6; anté dated August 22, 1850.

*Claim.*—"I wish it to be understood, that I do not claim as my invention, any of the several parts of the apparatus in themselves, but what I do claim as my invention, is, 1st, the employment of a liquid uncongealable at the low temperature at which it is required to keep the engine, to receive the heat of the water to be congealed, and give it out to the expanding air.

"2d, I claim the employment of an engine, for the purpose of rendering the expansion of the condensed air gradual, in order to obtain its full refrigeratory effects, and at the same time, render available the mechanical force with which it tends to dilate, to aid in working the condensing pump, irrespective of the manner in which the several parts are made, arranged, and operated.

"3d, I claim supplying the water gradually and slowly to the freezing vessels, and congealing it by abstracting the heat from its under surface, substantially as herein set forth.

"And lastly, I claim the process of cooling or freezing liquids, by compressing air into a reservoir, abstracting the heat evolved in the compression, by means of a jet of water, allowing the compressed air to expand in an engine surrounded by a cistern of an unfreezable liquid, which is continually injected into the engine and returned to the cistern, and which serves as a medium to absorb the heat from the liquid to be cooled or frozen, and give it out to the expanding air."

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11. For an *Improvement in Purifying Illuminating Gas;* Florentine Joseph de Cavaillon, Paris, France, May 6.

"My invention consists in the preparation of purifiers for illuminating gas, whereby I am enabled greatly to reduce the cost of purification, as conducted on the old plan, by a considerable diminution in the consumption of lime."

*Claim.*—"What I claim as of my own invention and discovery, is the purifying powder for illuminating gas, said powder consisting of sulphate of lime, either natural or artificial, in connexion with some inert substance or substances, partly inert and partly rendered purifiers, when compounded in the proportions substantially as herein described."

12. For a *Machine for Assorting Screw Blanks, etc.;* Thomas J. Sloan, City of New York, May 6.

*Claim.*—"What I claim as my invention, is the combination of the series of shifting ways, with the main or stationary ways, for the purpose and in the manner substantially as specified.

"And I also claim the detector, substantially as specified, in combination with the stationary and the shifting ways, substantially in the manner and for the purpose specified."

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13. For an *Improvement in Straw Cutters;* Jonathan Sullivan, Lexington, North Carolina, May 13.

*Claim.*—"Having thus fully described my improved straw cutter, what I claim therein as new, is in combination with the tooth-grooved cylinder and curved stationary knives, the cleaners, *g g*, arranged and operating substantially as herein represented and fully shown."

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14. For an *Improved Method of Supporting the Vanes of Aquatic Velocimeters;* John R. St. John, City of New York, Assignor to James Renwick, George F. Barnard, and Edward B. St. John, City of New York, Trustees of the St. John's Compass and Log Manufacturing Company, May 13; anté dated December 27, 1850.

*Claim.*—"Having thus described my invention, and set forth the means I employ, and the differences between my invention and those that are known to have preceded it, I do not intend to claim any of the parts herein described, as taken separately; all are well known and in common use.

"But what I do claim as new and of my own invention, is the attaching the disk, or plate *a*, to the sliding frames *b* and *c*, which frame *c*, carries the shaft *d*, of the paddle blades B, when said frame and plate are fitted to be lowered into or raised out of a tube A, in such manner that when in place for use, the plate *a*, prevents any indirect current of water from ascending into, or descending out of the tube A, to disturb or destroy the accuracy of the instrument, leaving the paddle blades B, subject only to the direct action of the vessel's progress through the water, substantially as described and shown."

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15. For an *Improvement in Planing Machines;* Rufus Bixby, Cyrus S. Bixby, and John Garst, Dayton, Ohio, May 13.

"Our invention relates to that form of planing machinery, in which stationary planes and tonguing and grooving cutters are employed.

"It consists, first, in an improvement in the form and arrangement of the thicknessing planes; and, second, in the employment of an endless chain or band, working in a recess in one or both sides of the grooving cutters, to prevent the recesses at the back of the cutting edges being choked or clogged by the shavings or dust produced in cutting the groove in the stuff."

*Claim.*—"What we claim as our invention, is the employment on one or both sides of the grooving cutters *b b b*, of a chain or band *c*, applied and operated in the manner substantially as and for the purposes herein described."

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16. For an *Improved Apparatus for Relieving the Helmsman from the Shock of the Rudder;* Charles Hoskyns, New Orleans, Louisiana, May 13.

"The nature of my improvement consists in the addition of a starboard and larboard pawl and ratchet, acting reciprocally with the wheel and rudder, through the medium of a helical motion, for the purpose of protecting the helmsman against the violence of the sea."

*Claim.*—"What I claim as my invention, is the combination of two sets of pawls, between which two sets of pawls, a wheel is placed loose upon the shaft, having an endwise motion thereon, by means of the male and female screw, as described; said wheel being provided with a hub, so fitted as to disengage the pawls, when the hub arrives at the limit of its end play in either direction; the result being that the rudder secures itself through the agency of the pawls, and is unlocked so as to be free to move in either direction, by the first motion of the same wheel which afterwards moves the rudder. In other

words, I claim the combination of the hub secured to the wheel, the male and female screws, or their equivalents, and the ratchets and pawls, substantially in the manner and for the purposes described in this specification."

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17. For an *Improved Apparatus for Indicating the Height of Water in Steam Boilers, etc.;* George Faber, Canton, Ohio, May 13.

*Claim.*—"What I claim as my invention, is the combination of the chamber D, with the boiler or other vessel, in which the height of fluids is to be measured, by means of tubes, so formed and attached as to act as springs, to indicate the height of the water at any time within said chamber, for the purpose and substantially in the manner herein set forth."

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18. For *Improvements in Flouring Apparatus;* James M. Clarke, Lancaster, Pennsylvania, May 13.

"My several improvements have for their objects, the production of a compact flouring mill, in which all the operations of grinding, bolting, &c., are perfectly performed, and the different products of the wheat separated and delivered at different openings; and the whole apparatus being contained in a few cubic feet, and from the small number of parts, and their concentric arrangement, a great saving of power is experienced by obviating friction, and at the same time, each part is made capable of accurate adjustment."

*Claim.*—"Having thus described my improvements, what I claim as new therein, is, 1st, the arrangement of the "hopper boy" revolving on the same centre as the stone, and the chamber beneath the stone, by which the flour is cooled as it is conveyed to the centre opening of the bolt, substantially as set forth.

"2d, I claim the annular or endless conveyors for carrying the flour, &c., in the several annular chambers to the spouts, the same being operated in the manner herein described.

"3d, I claim in combination therewith, the air passage W, for returning the particles of flour, which would otherwise escape to the centre hole of the floor of the bolting chamber, to be drawn in again by the draft, substantially in the manner set forth."

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19. For a *Crane Hinge of Doors, Shutters, etc.;* Ezra Ripley, Troy, New York, May 13.

*Claim.*—"What I claim as my invention, is the crane door hinge, constructed in the manner and for the purpose as herein substantially represented and set forth."

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20. For an *Improvement in Setting Teeth;* Adolph F. Ahrens, Philadelphia, Pennsylvania, May 13.

"The nature of my invention consists in attaching the tooth to the plate, by means of a wedge-formed pivot, soldered or otherwise affixed to the plate, the tooth being provided with a corresponding recess, into which the pivot accurately fits, when the said pivot is covered and the recess lined with platinum, and the union of the two is effected by the use of pure tin."

*Claim.*—"What I claim as my invention, is attaching artificial teeth to a plate in the roof of the mouth, by means of a wedge-formed recess in the tooth, and a pivot of corresponding shape, soldered or otherwise attached to the plate, when the union of the two is effected by the use of platinum and tin or solder, substantially in the manner and for the purpose specified."

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21. For an *Improvement in Setting Teeth;* Adolph F. Ahrens, Philadelphia, Pennsylvania, May 13.

"The object of my invention is twofold: 1st, to obviate the many difficulties heretofore attendant upon attaching the teeth to the plate, which is fitted against the roof of the mouth; also, to provide a means of increasing or decreasing the length of the tooth, without removing the setting; an operation both expensive and disagreeable."

*Claim.*—"What I claim as my invention, is securing artificial teeth to a plate in the

roof of the mouth, by means of a rebate in the inner face of the tooth, and a slide fitting the same, and soldered or otherwise attached to the plate in the mouth, for the purposes and in the manner described."

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22. For an *Improvement in Brick Presses;* Joseph Grant, Providence, Rhode Island, May 13.

*Claim.*—"What I claim as my invention, is, 1st, the form of the pressing plates, *n*, *n*, *n*, thicker at one edge than the other, as shown, and for the purpose described.

"2d, The motion of the followers or plungers, $E^2$ $E^2$ $E^2$, by rollers moving in fixed grooved channels, F F, and acted upon by revolving cams, *k k*, producing a drop movement, and operating as herein shown and explained.

"3d, Propelling the machine forwards by means of wheels D, D, keyed on the mould cylinder shaft, for the purpose of depositing the bricks as made, in regular layers for drying."

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23. For *Improvements in Saw Mills;* Martin Rich, Fairfield, Wisconsin, May 13.

*Claim.*—"Having thus fully described the nature of my improvements, and the manner in which they operate in producing the desired effect, what I claim as my invention is, 1st, the tightener and key, and the manner in which they are used in tightening the dogs, as herein set forth.

"2d, I claim the movable arm to regulate the thickness to be sawed, when changing from one thickness to another, in the same log, without taking the dog out of the log, as herein described.

"3d, I claim the placing the second dog upon the main plate, and adjusted by the bolt and key, constructed in the form and manner and for the objects and purposes herein before particularly set forth.

"No other part of the said above described dogs do I, in this my specification, claim as new or original, excepting such as above enumerated."

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## MECHANICS, PHYSICS, AND CHEMISTRY.

### *Description of a Boiler for Generating Steam by the Burning of Anthracite. Patented July* 16, 1850, *by* F. P. Dimpfel, *Philadelphia, Pennsylvania. (With a plate.)*

The construction of a boiler fitted for the combustion of anthracite, without the very great injury received in ordinary constructions from the intense local heat from that fuel, the difficulty of managing the fire, and the silicious nature of its ashes, has long been a desideratum, both on account of the notable economy to be thus introduced into our steam engines, and because it appeared a sad reproach upon our ingenuity that the very locomotives which brought down the anthracite from the mines should be compelled to use wood or bituminous coal for fuel.

Many efforts have been made to solve this important problem, but with no very notable success, until the invention of Mr. Dimpfel, which appears to have been, after a sufficient trial upon the Reading Railroad, perfectly successful. We have therefore great pleasure in presenting our readers with a copy of the specification of Mr. D's patent, with an engraving (Plate IX.) and the dimensions of his engine.

*The Schedule referred to in these Letters Patent, and making part of the same.*

Be it known that I, F. P. Dimpfel, of Philadelphia, in the State of Pennsylvania, have invented certain new and useful Improvements in

Steam Boilers and Generators, in which fig. 1 is a longitudinal vertical section of a boiler, such as would be adapted to a locomotive; fig. 2 a cross section of the same; and that the following is a full, clear, and exact description of the construction and operation of the same. The same letters indicate like parts in all the figures.

The principle of the first part of my invention relates to the employment of tubes or pipes within a boiler, which communicate at both ends with the body of water in the boiler, and through which the water circulates, and consists in making such tubes or pipes, with one end bent up, when such bent up ends are attached to the crown plate of the boiler, or the plates forming the sides or end of the fire-box or flue, at or near the junction with the crown plate, provided the other end is attached to a water space of the flue, and at or near the end of the same, substantially as hereinafter described, whereby the water is caused to circulate freely through such tubes, and is freely delivered out of the bent up ends without any counteracting effect, and the circulation of the water through the tubes is always insured in the same and required direction, the bends in the said tubes at the same time giving the required elasticity to yield to the expansion and contraction due to the changes of temperature to which they are necessarily exposed.

And this part of my invention also consists in combining such bent tubes with a water bottom of any form whatever, or other bottom water communication which will freely supply water to the space with which the straight ends of the tubes connect, by means of which combination a full supply of water is given to insure the circulation through the tubes, and which at the same time prevents the overheating of the plate or plates to which the straight ends of the tubes are attached, and consequently avoids the evil effects which otherwise would take place, for the heating of the plates tends to repel and drive up the water, and hence prevents it from entering the tubes freely. But by the arrangement herein specified, the water is supplied to this space freely, and by the rapid circulation prevents, in a great measure, the heating of the plate to which the ends of the tubes are attached, and hence admits of the more free circulation of the water into the tubes.

This part of my invention also consists, in connexion with the bent tubes attached at one end and within some part of the flue, in attaching the bent up ends of the said tubes to the crown plate or roof of the fire-box, that the current of water through the tubes may be discharged over the said crown plate or roof, and thus prevent the overheating thereof, for the heat in the fire-box acts upwards, and impinges on the under surface of this plate, and tends to heat it to a high degree; and if by accident the water be suffered to sink below, it soon becomes overheated, and endangers the safety of the boiler. But by attaching the bent up ends of the tubes to this plate, the current of water discharged by them will flow over the upper surface of this plate, and thus keep it covered with water even after the level of the body of water in the boiler has fallen below it. In this way the parts of the boiler most exposed to the effects of intense heat are fully protected.

The second part of my invention consists in combining with the bent up tubes attached to the crown plate of the fire-box, the making of such

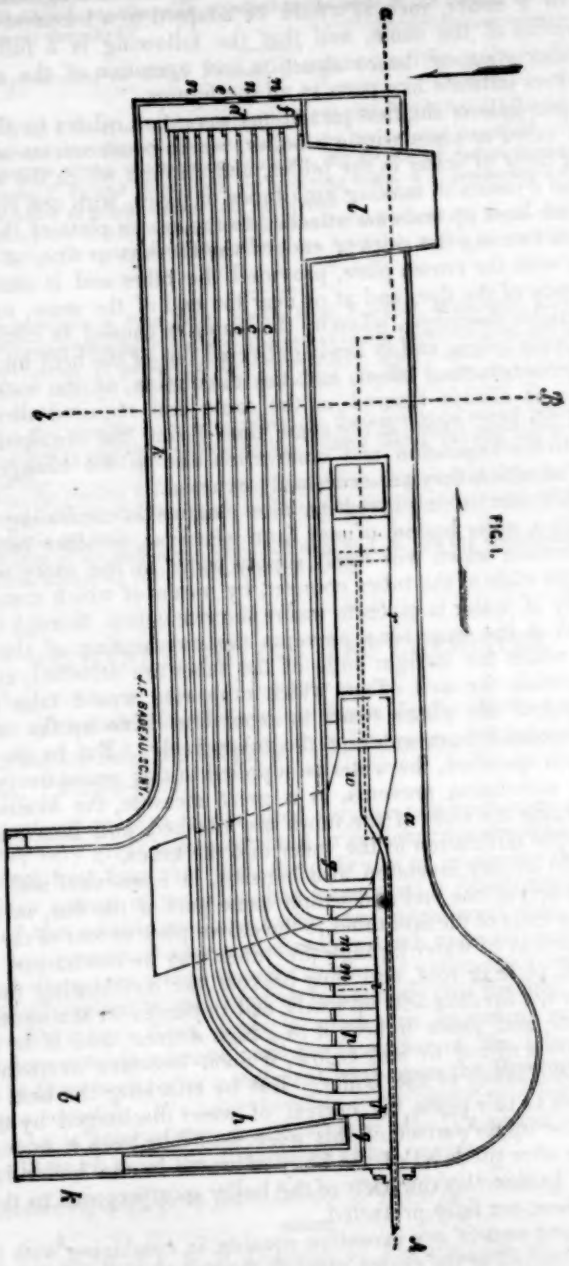


FIG. 1.

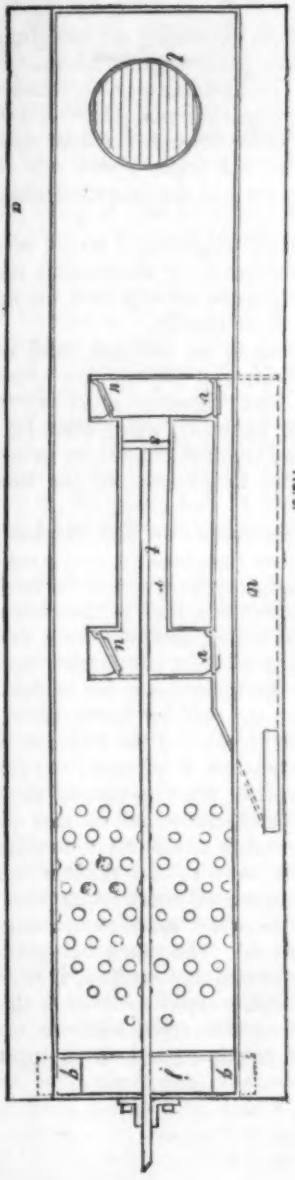
FIG. 3.

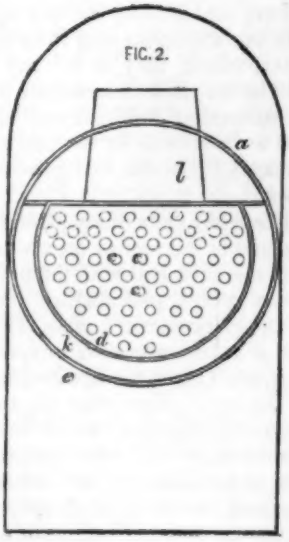
FIG. 2.
a
l
k
d
e

crown plate with a ring or projection around the edges thereof, the better to retain on its surface the water discharged into it by the circulation through the tubes.

The third part of my invention consists in extending the bent up ends of the tubes above the surface of the crown plate or other plates, on one side of which the fire, or products of combustion, acts, to which they are attached, when the other end of the tubes communicate with a water space or body of water below or further from the fire-box than the said bent up ends, whereby the disturbance of the water above the crown sheet, or other plate to which the bent up ends of the tubes are attached, is avoided.

And the last part of my invention consists in giving a forced circulation to the water in steam-boilers, or generators, by mechanical means, whereby the water is caused to pass with greater velocity over the heated surface, and thereby to take up the heat more rapidly.

In the accompanying drawing (*a*) represents the external shell of the boiler, which may be of any desired form, and (*b*) the fire chamber. Within the shell is arranged a series of water tubes or pipes (*c*), which are secured at the back end to a vertical plate (*d*), which plate (*d*) is at such a distance from the end plate or head (*e*) of the boiler, so as to have a space (*f*) for the free admission of water to this end of the tubes or pipes.

The other ends of said tubes or pipes are curved or bent upwards, and attached to the roof or crown plate (*g*), which runs back to, and is connected at the back end with the plate (*d*) before described, and at the front end with a vertical plate (*h*), or lining of the furnace, and at the sides with the upper edges of a plate (*i*), within the boiler, and at such a distance from it as to leave a water space (*j*) all around, and communicating with the space (*f*) at the back end, and with the water space (*k*) surrounding the furnace. This plate (*i*), together with the roof or crown plate, constitutes the fire-flue, which leads from the furnace to the chimney (*l*), so that the flame and other products of combustion, in passing from the furnace to the chimney, act first on the curved or bent up part of the tubes or pipes, and then, in passing towards the chimney, act on and impart heat to the external surface of all the water tubes or pipes, the most intense heat being applied to the curved or bent ends of the tubes which first receive the action of the heat. The products of combustion also heat the plate (*i*), which is the inner shell of the water space surrounding the flue, and which constitutes the water bottom. The tubes being bent or curved upwards, as the water in them is heated and rarified, it will tend to rise in the curved end, and thus establish a rapid circulation through the entire length, and as their other end is connected with the body of water at the back, and where the water is not heated to so intense a

degree, the circulation in the tubes or pipes will be fully supplied. The water space (*j*), between the plate (*i*) and the outer shell of the boiler, as well as the space (*f*) at the back, are closed at the top from the back to the space (*k*), around the furnace or fire-box, and the crown plate or fire roof to which the bent up ends of the tubes are attached, is surrounded by a rim (*p*). Two or more tubes (*q*) form communications between the space above the crown plate and the lower end of the space (*k*), around the fire-box; and this space (*k*) in turn communicates, as indicated by the arrows, with the space (*j*), which, as stated, constitutes the water bottom.

The effect of this arrangement will be that, as the water above the crown plate or fire roof cannot pass down the side or back spaces (*j*) and (*f*), it will run down the tubes (*q*) to the bottom or lower part of the spaces (*k*) surrounding the furnace or fire-box, and thence through the water bottom to the space (*f*) to supply the circulation in the tubes. The current thus supplied to the space (*f*), which cannot rise above the covering of the said space (*f*), by reason of its being closed up at top, will effectually supply the tubes, for if the said space (*f*) were open at top, and not connected with the water bottom, the heat which the plate (*d*) receives from the impingement of the products of the combustion in passing through the flue, would have the effect to repel the water from the surface of the plate, and to induce an upward circulation in the said space (*f*) so rapid as not to give an adequate supply of water to the tubes.

And as the curved and bent up ends of the tubes are either directly over or nearest the fire chamber, they will be more highly heated than the rear ends, so that the water by its circulation through the tubes or pipes will move in a direction the reverse of the current of heat, as it passes from the fire chamber to the chimney, thus increasing the absorption of heat by the water.

The bent up ends of the tubes are extended above the roof or crown plate, as at (*m*), which will induce a more rapid circulation, and avoid the agitation of the water on the surface of the roof around the tubes.

The shell of the boiler at the horizontal end of the tubes or pipes may be perforated as at (*n*) with a series of holes, corresponding with the bore of the tubes, for which one large hole for the whole series, covered with a plate in the manner of a man-hole, may be substituted, for giving access to the tubes or pipes, for cleansing or repairing them.

A short distance above the top flue-plate there is a cylinder or case (*r*), provided with a reciprocating piston (*s*), the rod (*t*) of which passes through the head of the boiler, that it may be connected with any moving part of the engine, or any other first mover, to give it a reciprocating motion. The said cylinder is provided on one side with two induction valves (*uu*), one at each end, and on the other side with two eduction valves (*vv*), discharging into a pipe (*w*), leading down into one of the outer spaces. It will be obvious from this, that the reciprocating motion of the piston will produce a current of water down the water space in which the pipe is located, and that this will induce a circulation through the boiler, to return the water to the induction valves of the cylinder, and in this way establish a circulation of the water over the heating

surface of the boiler with a velocity dependent on the capacity of the cylinder and the motion of the piston.

I do not wish to limit myself to the precise construction herein above described, nor to the employment of all the various parts of my invention in connexion, as the construction and arrangement of parts may be variously modified, within the range of the several parts of my invention, and improved results can be obtained from the use of one or more of the improvements enumerated as constituting the several parts of my invention, without the others, although the best results will be obtained when all of them are used in connexion, as they either depend upon or assist one another in effecting the special purposes contemplated by me, viz., the more rapid, safe, and economical generation of steam.

As to the mechanical means for producing a forced circulation of the water through the boiler, any other known mechanical arrangement may be substituted for that herein described, such as rotating valves or paddles, duck-foot paddles, and a variety of others not necessary to enumerate.

What I claim as my invention, and desire to secure by Letters Patent, is, First, arranging a series of bent water tubes within the flue space of a boiler, and connected at each end with the body of water in the boiler, substantially as herein described, by means of which the circulation of water is greatly increased, and the injurious effects due to expansion and contraction avoided, substantially as described.

Second, I also claim surrounding the crown sheet, to which the ends of circulating tubes, or their equivalents, are attached with a rim, substantially as and for the purpose specified.

Third, I also claim extending the ends of the tubes, or the equivalents thereof, above the crown plate or roof of the fire-box, or any other plate or plates, one side of which is fire surface, to which they are attached, when the other or lower end communicates with a water space or spaces below or beyond the plate to which the upper ends are attached, substantially as and for the purpose specified.

I am aware that a patent was granted to Richard Prosser, in England, February, 1839, (see Newton Journal, Vol. xv, Conjoined Series, page 271,) in which are represented circulating tubes, with one end projecting above a plate. I do not claim such arrangement, believing that described by me to be substantially different, and producing an entirely different effect.

Fourthly and lastly, I claim giving a forced circulation to the water through the boiler or generator by mechanical means, substantially as and for the purpose specified.

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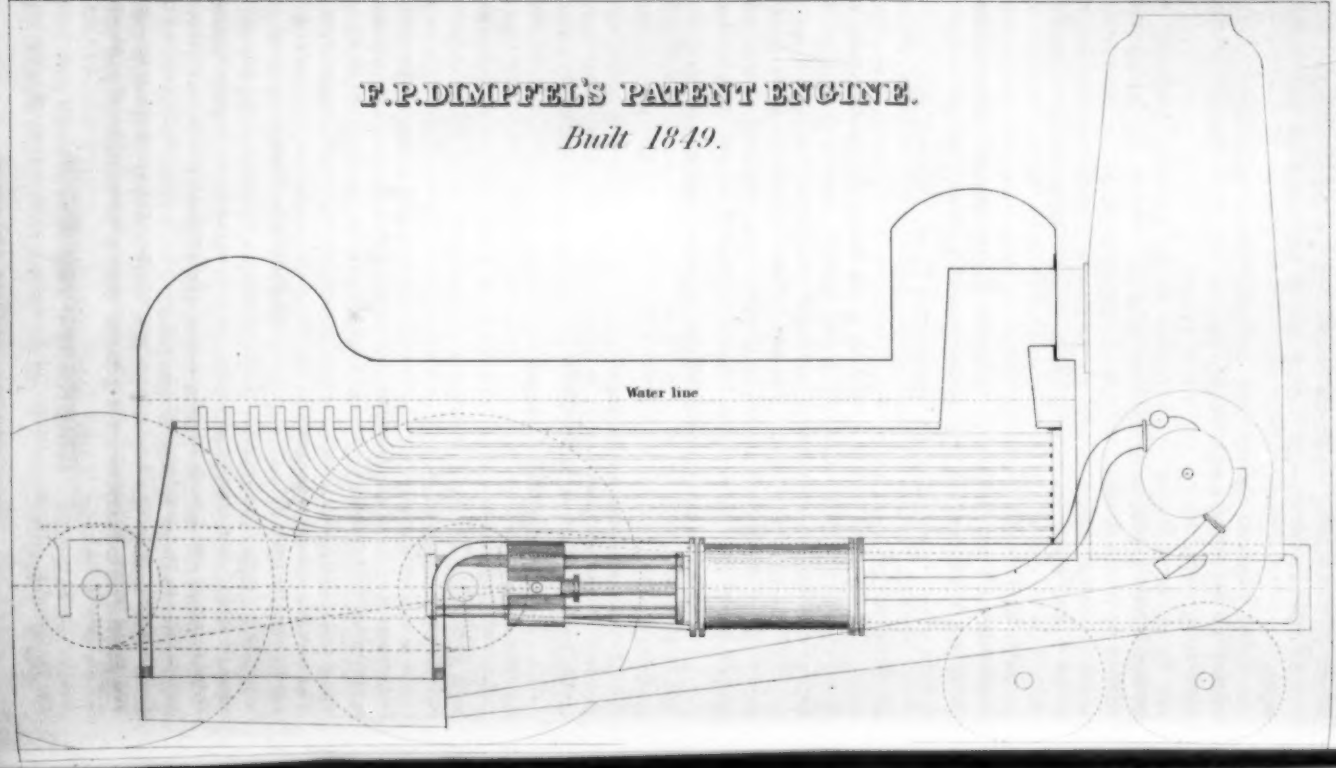
This engine has been in daily use for several months, running over six thousand miles with anthracite coal exclusively.

The fire-box is of iron, and only two inches water space (in other engines usually three to four inches) around it. There is not any perceivable evidence of the least injurious effects either on the sides of the fire-box nor tubes.

This engine is provided with a patent apparatus for the purpose of returning a portion of the unconsumed gases. It retains the cinders, and with bituminous coal the smoke is consumed.

# F. P. DIMPFEL'S PATENT ENGINE.

*Built 1849.*



Within this apparatus is a blower, which is driven by the exhaust steam, and after it has performed this duty it is led back into the tender for the purpose of heating the water.

The following are the dimensions of the engine:—

| | Feet. | Inches. |
|---|---|---|
| Length of Boiler, | 10 | 8 |
| Diameter, | | 42 |
| Inside of Fire-Box, | 56 in. long × 37 in. wide. | |
| Water Space around Fire-Box, | | 2 |
| Depth of Fire-Box, | 4 | |
| Number of Tubes, | 99 | |
| Average Length of Tubes, | 13 | |
| Diameter of " (outside), | | 2 |
| Fire Surface in Fire-Box, | 59½ sq. ft. | |
| " Flue Part, | 104½ " | |
| Heating Surface of Tubes, | 671½ " | |
| Total Heating Surface, | 835½ " | |
| Diameter of Cylinders, | | 15½ |
| Length of Stroke, | | 26 |
| Number of Driving Wheels, connected, | 4 | |
| Diameter " | 6 | |
| Weight of Engine in Working condition, | 24½ tons. | |
| " on Driving Wheels, | 16 " | |
| " of Water Contained in Boiler, | 1¼ " | |

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*Report on the Passages of the "Fawn," Screw Steamer.**

The *Fawn* is a Post-office packet belonging to the French government, and running from Dover to Calais. She was built of iron, by Mr. Norman, at Havre, in 1846, and the engines made by John Penn and Son, engineers, of Greenwich; they are oscillating engines of 64 horse power each; 42 inch cylinders, 3 feet stroke; geared, 5 to 1, to screw shaft; and are very nearly a copy of those made by Messrs. Penn for H. M. Yacht *Fairy*.

*Report to the Minister of the Marine and of the Colonies, upon the Fawn Mail Packet Boat, of* 120 *Horse Power, Propelled by the Screw, Constructed by M. Moissard, Engineer of the Marine, and Engines by John Penn & Son, of Greenwich.*

At a time when the high freights of the steam-vessels employed to carry the mails, render urgent the construction of special mail packets, it cannot be inopportune to lay before the Minister of the Marine, certain results which I have been enabled to verify; and to call his attention to one of the most perfect constructions of M. Moissard, Engineer of the Marine, Member of the Council of Works. I speak of the results obtained by the *Fawn* screw packet-boat of 120 horse power, in carrying the mails between France and England, since the month of August, 1847.

The dimensions of this vessel, which can work all her ports—her speed of upwards of 12 knots an hour, and in many superior cases 13 knots—the ease with which she can be worked between the most confined jetties—her excellent sea-going qualities, in steaming as well as

* From the London Architect, for April, 1851.

sailing—and her low consumption of fuel, insure for the *Fawn* an incontestable superiority over all other classes of vessels in existence. This superiority is recognised by the English Admiralty, who are surprised at the results obtained, and the passages made by this packet when the paddle boats, with paddle-wheels of the most improved construction, dare not leave the harbor. It suffices for the rest, to give an abstract of her log-book during a navigation of twenty-two months in the British Channel, voyages of the day and night, performed in all winds and weather, that no doubt on this head can be possible. This is not the place to enter into all the circumstantiated details of construction, the disposition of the vessel and of the machinery, of which complete plans are in the hands of M. Moissard. My sole object is, by a conscientious exposition of the results obtained, to call attention to the best screw boat that France possesses. Here are, however, some of the principal data:—

| | Feet. | Inches. |
|---|---|---|
| Length between the perpendiculars, | 132 | 9 |
| Extreme breadth, | 20 | 4 |
| Breadth at the load water-line, | 19 | 8 |
| From under side of deck to keelson-plate, | 10 | 4 |
| Draft of water, Forward, | 6 | 0 |
| Draft of water, Aft, | 6 | 10 |
| Draft of water, Mean, | 6 | 2 |
| Difference, | | 10 |
| Weight of the machinery, | 53 tons. | |
| Weight of the boilers and accessaries, | 11 " | |
| Diameter of the cylinders, | 42 inches. | |
| Stroke of piston, | 3 feet. | |
| Pressure in the boilers, | 14 lbs. | |
| Strokes of piston per minute, | 40 to 42 | |
| Revolutions of the screw per minute, | 200 to 210 | |
| Pitch of the screw, | 7 ft. 9 inches. | |
| Displacement, Forward, | 92·927 tons. | |
| Displacement, Aft, | 95·725 " | |
| Total | 188·652 | |

*Speed.*—The heavy winds and seas lessen the speed of the vessel; on the other hand, it is admitted, under these two circumstances, that the British Channel is one of the most advantageous places for the trials; when, notwithstanding, the following figures are obtained upon 226 voyages:—

Mean speed (maximum) 14·82 knots.
Mean speed (minimum) 8·76 knots.
Mean speed (average) 12·30 knots.

An incontestable superiority in speed must be recognised in this packet boat. The cost of obtaining this result should also be given.

*Coals.*—The consumption of fuel, calculated for a given time and distance run, gives the following table:—

*Consumption of Fuel.*

| Per hour of passage. | Per 24 hours. | Per mile run. | Per 100 miles. |
|---|---|---|---|
| 1,757 lbs. | 41,800 lbs. | 141·68 lbs. | 14,168 lbs. |

Number of miles run in 24 hours, 295.

The engines are by Penn. She has but one air-pump and one condenser, which are placed the one upon the other, both being with the

cylinders in the centre of the vessel's breadth. This arrangement leaves the circulation free inboard, and renders the working and repairing of the machinery very easy. The tubular boilers, in two compartments, which can be worked independently of each other at pleasure, supply plenty of steam. A staff of five men is sufficient for all purposes. In conclusion, during 22 months of service, neither the vessel nor the machinery have required any work beyond that of ordinary repairs. Here is a table of the voyages, extracted voyage by voyage, and added together month by month:

*Table of the Voyages, Speed, and Consumption of Fuel, of the Fawn Screw Packet-boat, of* 120 n. r., *during the years* 1847-8-9.

| Dates of the Voyages. | Number of the Voyages. | Mean consumption of coal for the month, going and returning. | Mean time for the month for going and returning. | Corresponding speed per hour expressed in geographical miles. | Maximum time for a half passage for the month. | Corresponding speed per hour in miles. | Minimum time for a half passage for the month. | Corresponding speed per hour in miles. |
|---|---|---|---|---|---|---|---|---|
| | | lbs. | h. m. | knots. | h. m. | knots. | h. m. | knots. |
| 1847, August, | 10 | 6160 | 3 31 | 13·08 | 2 15 | 10·20 | 1 35 | 14·40 |
| September, | 13 | 6439 | 3 38 | 12·66 | 2 39 | 8·82 | 1 27 | 15·84 |
| October, | 10 | 6549 | 3 33 | 12·96 | 2 15 | 10·20 | 1 33 | 14·82 |
| November, | 9 | 6439 | 3 39 | 12·60 | 2 45 | 8·34 | 1 27 | 15·84 |
| December, | 9 | 6681 | 3 35 | 12·78 | 2 41 | 8·52 | 1 30 | 15·80 |
| 1848, January, | 10 | 6754 | 3 39 | 12·60 | 2 43 | 8·46 | 1 41 | 13·62 |
| February, | 12 | 6638 | 3 55 | 11·70 | 3 10 | 7·56 | 1 29 | 15·48 |
| March, | 13 | 6641 | 3 46 | 12·18 | 2 30 | 9·18 | 1 32 | 15·00 |
| April, | 9 | 6769 | 3 47 | 12·12 | 2 20 | 9·84 | 1 36 | 14·34 |
| May, | 10 | 6556 | 3 38 | 12·66 | 2 19 | 10·32 | 1 35 | 14·52 |
| June, | 9 | 6468 | 3 49 | 12·01 | 2 35 | 8·88 | 1 34 | 14·64 |
| July, | 12 | 6600 | 3 50 | 12·00 | 2 32 | 9·06 | 1 61 | 15·12 |
| August, | 4 | 6710 | 3 59 | 11·52 | 2 35 | 8·88 | 1 32 | 15·00 |
| September, | 10 | 6204 | 3 38 | 12·66 | 2 30 | 9·18 | 1 32 | 15·00 |
| October, | 10 | 6138 | 3 40 | 12·54 | 2 20 | 9·84 | 1 34 | 14·64 |
| November, | 15 | 6292 | 3 54 | 11·76 | 2 45 | 8·34 | 1 34 | 14·64 |
| December, | 9 | 6820 | 4 12 | 10·92 | 4 3 | 5·64 | 1 33 | 14·82 |
| 1849, January, | 11 | 6558 | 4 03 | 11·34 | 3 30 | 6·54 | 1 34 | 14·64 |
| February, | | | | | | | | |
| March, | 10 | 6160 | 3 38 | 12·66 | 2 35 | 9·90 | 1 34 | 14·64 |
| April, | 10 | 6512 | 3 31 | 13·08 | 2 16 | 10·14 | 1 32 | 15·00 |
| May, | 11 | 6318 | 3 41 | 12·48 | 2 20 | 9·84 | 1 29 | 15·48 |
| June, | 10 | 6193 | 3 36 | 12·72 | 2 15 | 10·20 | 1 35 | 14.52 |
| Total. | | 142599 | 82 42 | | 57 53 | | 33 59 | |
| Mean for one voyage taken from 226 voyages. | | 6507 | 3 46 | 12·30 | 2 37 | 8·76 | 1 33 | 14·82 |

*Observations.*—The Sunderland coal alone burned badly. After repeated trials, it was found necessary to use equal portions of Cardiff and Sunderland.

From the month of October to the month of February, the time of the repairs, the bottom tube plate on the port side was much out of order, it was necessary to proceed with a low pressure of steam.

The figures carried to this table are exact. The distance between Calais and Dover is, by the compass, 22 geographical miles; and in

counting one mile over and above (which has been done in the table), for the ground lost in passing the bar, entering the harbor, and the meeting of ships, this will be less than the actual distance run. The time occupied in the passage is effectually checked, for the postal authorities notice the time of departure as well as the arrival of the mails. This boat leaves Calais at 10 o'clock at night, and starts from Dover at 3 in the afternoon. One of her voyages is, therefore, constantly performed during the night. In the double passage, the favorable and adverse winds and currents balance each other; consequently, the average of 12.30 knots is less than the real speed of this boat, for the two following reasons:—First, the night passages are frequently made at a reduced speed, for stopping, sounding the bell to give and receive notice of approach from the numerous vessels passing in the Channel; secondly, the vessel is got under weigh at a fixed hour, for, whatever may be the weather, it is absolutely necessary the mail should arrive at its destination.

*Comparison with the Steam Vessels in the Navy.*—It is interesting to place by the side of these results, those obtained from some of the steam-vessels in the Navy, allowing for them the most favorable figures, both in speed and consumption of fuel, and taking the average results of the *Fawn;* admitting that

The vessel of 160 h. p. consumes 37,400 lbs. per 24 hours at a speed of 8 knots by log,
" 220 h. p. " 50,600 lbs. " " 10 "
" 450 h. p. " 110,000 lbs. " " 11 "

the following comparative table is the result.

| Power of the Vessels. | Miles run in 24 hours. | Consumption of Fuel. | | | | |
|---|---|---|---|---|---|---|
| | | per 24 hours. | per mile run. | per 100 miles. | per 295 miles. | for the journey, the consumption of the *Fawn* taken as 1. |
| | h. p. | lb. | lb. | lb. | lb. | |
| Steamer of | 450 | 264 | 110000 | 416·65 | 41665 | 122914 | 2·98 |
| do. | 220 | 240 | 50600 | 210·82 | 21082 | 62194 | 1·48 |
| do. | 160 | 192 | 37400 | 196·59 | 19659 | 57646 | 1·37 |
| *Fawn* of | 120 | 295 | 41800 | 141·68 | 14168 | 41800 | 1·00 |

The vessel of 160 horse power is the one in which the consumption of fuel approaches the nearest to that of the *Fawn*, without equalling it, however; but this is also the vessel in which there exists the greatest difference in the time occupied in running a given distance, and it is under such circumstances where the speed is of immense value in an advice boat.

I will dwell no longer upon this subject. It is easy to deduce from these given figures any comparison at pleasure, such as the expense of fuel, and, independent of expense, the amount of oil, tallow, &c., used in a given distance.

I cannot help remarking that all these differences in favor of the *Fawn*, would be still more apparent if the constant proximity of the land, the shortness of the passage, the nature of the service, and the continual

passing of vessels, did not frequently hinder, in a great measure, the full assistance of the sails.

When the *Fawn* unites the action of sailing with the steam power, her speed is easily brought to from 13 to 14 knots an hour, and frequently more. With the sails alone, and the screw disconnected, she makes 9 to 9·5 knots. She makes 5 to 5·5 knots with the screw in connexion. The operation of disconnecting the screw is performed in a few minutes.

She is schooner-rigged, with three masts. Her small amount of canvas, admirably adapted to the nature of the service, but inconvenient for working the ship, could be so modified, and above all so considerably increased, as to realize, in any service different to that of the Channel, all the speed and economy which this vessel could possibly obtain.

Under the report of the necessary crew, a great difference also exists between the *Fawn* and the smallest of the compared classes, the steam-vessel of 160 horse power; and the expense is but about one-third. Her crew is composed of twenty-one hands, as follows:—1 captain; 1 lieutenant; 1 channel pilot, acting as officer in charge; 1 chief engineer, 1 assistant engineer; 3 stokers; 1 sailing master, 1 boatswain; 8 sailors, 1 cabin boy; 1 cook, and 1 steward.

It remains established, by all which precedes, that no mail boat can compete with the *Fawn* in regard to speed and economy—that is to say, that all other mail boats would require more time, and consume more fuel, tallow, oil, &c., and take a more numerous crew, to perform the same journey.

(Signed.) DESCHAMPS,
S. Engineer of the Marine,
Superintendent of the Mail Packet-boat Service.

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For the Journal of the Franklin Institute.

## *A Series of Lectures on the Telegraph, delivered before the Franklin Institute. Session*, 1850–51. *By* DR. L. TURNBULL.

Continued from page 341.

Before concluding the subject of electro-chemical telegraphs, I would bring before my readers a communication from the distinguished French philosopher, the Abbe Moigno, author of the "Traité de Telegraphie-Electrique," although not agreeing with the sentiments expressed in my former communication; but I have introduced it in justice to Mr. Bain, and from respect to the opinion of M. Moigno.

*Communication on the Electric Telegraph.*—The President of the Society for the Encouragement of National Industry, (Session, May 8th, 1850,) announced that Mr. Bain had arranged in the hall his ingenious systemof electric telegraphing, of which M. Sequier had during a previous session given a description, which greatly interested the members of the society.

The Abbe Moigno was invited to give an explanation of this apparatus, to which invitation he quickly responded.

In this consists the ingenious mechanism of this apparatus, to which

the author has given the name of electro-chemical telegraph, to distinguish it from the electro-magnetic telegraphs now in use, provided it be deprived of the magnet.

The message wished to be transmitted, is written on a piece of long narrow paper by cutting with the aid of a punch, the letters of a very simple alphabet composed of points and horizontal lines. This band is rolled on a wooden cylinder, and then unrolls itself with the aid of a crank, so as to pass on a second metallic cylinder, which supports four little springs which communicate with the conducting wire of the telegraphic line; the metallic cylinder is connected with the pole of a battery of small volume and very simple construction.

The band of paper presents in turn, a covered part and a vacant space; this last represents the letters of the alphabet, whilst the covered parts are of paper, that is to say, an insulating substance. When the small springs rest on the covered parts, the circuit is not formed and the current does not pass, but so soon as the springs touch an empty place, they are in contact with the cylinder; from that time the communication is established, the current circulating, and arriving instantaneouly at the station. There a small style is attached to the conducting wire of the line; below this style turns a metallic plate, which is covered with a disk of paper, chemically prepared by dipping it at first in a solution of sulphuric acid, and afterwards in a solution of prussiate of potash. The plate and the damp disk with which it is covered, communicate with one of the poles of the battery at the station of arrival. The current is afterwards completed through the earth.

The despatch is transmitted in the following manner: at a given signal the style is applied to the chemical paper; at every empty space on the band of paper, which is unrolled by the crank, the current passes, and under its influence the point of the style, by the chemical action which it exercises, traces a point or a little line of a very dark color, which is the faithful representation of the letter which must be reproduced at a distance.

The band on which an entire page is written unrolls itself with extreme rapidity, the plate, drawn by a clock-like movement, turns also with great quickness. After 45 seconds the 1200 letters composing this page appear very neatly drawn on the disks of the chemical paper, and were thus faithfully reproduced, and would have gone two or three hundred leagues further without any difficulty. The movement printed on the plate is a spiral one, so that the successive lines do not supersede each other, but remain entirely distinct.

These are the advantages which the author attributes to his system of electro-chemical telegraph: 1st, more economy and simplicity in the primitive construction: 2d, more rapidity in the transmission of the despatches; a single wire with a good insulator can transmit 1200 letters a minute, or 20 letters a second, that is, ten times more than is customary: 3d, an electric current more feeble than is ordinary, suffices to cause the apparatus to work, and is consequently less exposed to the chances of interruption by the imperfection of the insulation, which results sometimes from the vicissitudes of the weather and other circumstances: 4th, more simplicity and economy in the correspondence, and superintendence: 5th, fewer chances of error in the despatches sent.

Bain's telegraph is in operation in England, from London to Manchester, and from Manchester to Liverpool, over an extent of 300 kilometres, (186½ miles,) and in America on a line of 2000 kilometres, (1242⅛ miles.)

The President begs Mr. Bain to receive the congratulations of the society, on his system of electric telegraphing, and he renders to M. Abbe Moigno the thanks of the society for the complaisance with which he has given clear and precise explanations on the mechanism and play of this system.—*Bulletin de la Société d'Encouragement pour l'Industrie Nationale, May* 8, 1850, *p.* 236.

Before giving an account of the various forms of electro-magnetic telegraphs, it will be proper to give a brief account of the science which investigates the relations subsisting between the electric, galvanic and magnetic fluids, as all the forms of telegraph I am about to describe depends on the power of the electric current to deflect a magnetic needle, or the power of the current to impart temporary magnetism to iron, or to produce electric currents by magnetic induction.

*Electro-Magnetism.*—The power of lightning to destroy, and reverse the poles of a magnet, and to convey magnetic properties to iron, which did not previously possess them, was noticed at a very early period of electrical science, and led to the supposition, that common electricity and galvanism would produce the same effect. Attempts were made to prove this fact, but no important results were obtained, until the late Prof. Œrsted, of Copenhagen, published in *Thompson's Annals of Philosophy*, for October, 1820, the important discovery he had made in the winter of 1819, which laid the foundation of the science of electro-magnetism. He ascertained that when a wire conducting electricity is placed parallel to a magnetic needle properly suspended, the needle will deviate from its natural prosition, which is thus expressed in Ampère's brief and universal terms: "*that the north pole of a magnet is invariably deflected to the left of the current which passes between the needle and the observer, who is to have his face towards the needle, the electric current being supposed to enter near his feet, and to pass out near his head.*" Likewise, that this deviation follows a regular law, which can be stated in four general rules: 1st. If the needle is above the conducting *wire*, and the electricity passes from right to left, the north pole of the needle will be moved *from* the operator. 2nd. If the needle is below the wire, and the electricity passes as before, the north pole of the needle will be turned towards the observer. 3rd. If the needle is put in the same horizontal plane with the wire, and is between the observer and the wire, the north pole of it will be elevated. 4th. If the needle is in like manner placed on the opposite side, the north pole will be depressed. To exhibit this effect well, the needle must be very near the wire. Other new and important facts were soon after discovered by Ampère and Arago, in France; Davy and Faraday in England, and our own illustrious Prof. Henry, then of Albany, New York. Ampère satisfactorily referred all the observed phenomena to the laws which govern the mutual actions of electrical currents, by means of a very ingenious hypothesis—that magnetism consists in electrical currents, revolving around the minute particles of a magnet, in planes perpendicular to its axis. This branch of science is also named electro-dynamics, which simply means electricity in motion,

while electricity at rest, is called statical electricity. The laws of electro-dynamical attraction and repulsion, experimentally established by M. Ampère, and which serve to explain all the known phenomena, may be plainly stated in a few general propositions.

Fig. 9.

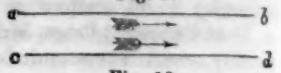
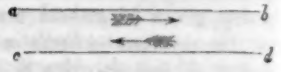


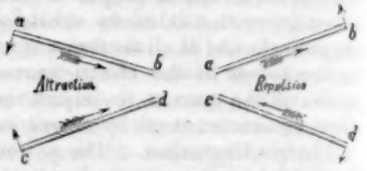

Fig. 10.




*Proposition* 1st. Parallel currents, (Fig. 9) flowing in the same direction attract each other, where *a b c d* are the currents, whose directions are indicated by arrows. They mutually repel when their directions are opposite, as in Fig. 10, *a b c d*.

*Proposition* 2*d*. Two currents attract each other when they both flow towards or from a certain point, if they are not in the same plane, as in Fig. 11. And they repel each other, if one approaches and the other recedes from that point, as in Fig 11.

Fig. 11.




*Proposition* 3*d*. These attractive forces (Fig. 12) vary in their intensity in the inverse ratio of the square of the distance—or, as the distance increases, so their force diminishes, as in Fig. 12.

Fig. 12.

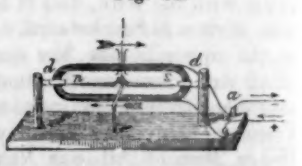
Fig. 13.

*Proposition* 4. The attraction or repulsion exerted by a current passing through a tortuous conductor, no matter how numerous its windings may be, is exactly equal to that which is produced by the same current when it follows in a straight line between the points as in shown fig. 13.

A magnetic needle is a galvanascope, by which the existence and direction of an electric current may be detected. It was early employed with this intention, by Ampère, but, as the deflexion took place only when the opposite ends of the battery were in connexion, and ceased when the circuit was broken, he inferred that electricity passes uninterruptedly through the battery itself when the circuit is closed, and that there is no action in the interrupted circuit.

A magnetic needle will not only indicate the existence and direction of an electric current, but may serve by the degree of deflexion as an exact measure of its force. When used for this purpose it is called a galvanometer, the first example of which was invented by Professor Schweigger, of Halle, in 1820, soon after the discovery of electro-magnetism, and was called by him an electro-magnetic multiplier; an example of this form of instrument is seen in Fig. 14. Various forms have been given to this instrument, as it is the basis of all the needle telegraphs.

Fig. 14.




A current of galvanic electricity not only determines the position of a magnet, but renders steel permanently magnetic. This was observed

nearly at the same time, by M. Arago and Sir H. Davy, who found, that when needles are placed at right angles to the conducting wire, permanent magnetism is communicated to them. Sir H. Davy succeeded in producing this effect, even with a shock of electricity from a Leyden jar. M. Arago, at the suggestion of M. Ampère, made a galvanic conductor in the form of a helix, or coil, into the axis of which he placed a needle, as seen in Fig. 15. This helix was simply a spiral coil of wire, the extremities of it being connected to the opposite poles of a battery, thus permitting an electrical circuit to pass through it. By this arrangement the current is almost at right angles to the needle, and as each coil adds its effect to that of the others, the entire action of the spiral helix is extremely powerful. In this way a needle can be completely magnetized in an instant, and this is the method now principally employed by artisans in the manufacture of compass needles.

Fig. 15.

When the conductors of a galvanic battery are brought near, or in contact with a quantity of iron filings, the filings will be attracted towards the conductors, and place themselves in the form of a ring around it. This action takes place while a current of galvanism is sent through the conductor, but as soon as that current is broken they fall off. By observation of this fact, M. Arago was led to the important discovery of what is termed magnetic induction by electrical currents. Namely, that a current of electricity passing through a conductor will induce, or make sensible, magnetic action in those bodies near it, which are capable of being magnetized. Arago was then the first to form a temporary magnet. That this property is magnetic, and not simply electrical, is shown by the fact, that the filings of other metals are not attracted in the same way. It likewise renders steel needles permanently magnetic when placed in the axis of the spiral helix or coil.

The word induction is here used to express that power which electricity has to make magnetic action apparent to our senses. That the effect of the galvanic current upon the iron filings and needles is one of magnetic induction, is proved by the reality, that they acquire this property without contact with, and even at a distance from, the conducting wire.

Some philosophers have ascribed the formation of iron filings into a circle around the conducting wire, to the influence of a magnetic current revolving about it perpendicular to its axis, and not to any action induced in the filings themselves. Dr. Bache, the eminent Professor of Chemistry, in the Jefferson Medical College of this city, many years ago publicly advocated the idea, that the filings were not inert agents in this movement. To prove it, he instanced the evidence that when their ring around the wire is broken, they immediately fall off, even when a current of galvanism is progresssing along the conducting wire; he maintained the opinion that they assumed the ring-like form, because of the magnetism induced in them, and the argument he has adduced in its favor is certainly quite conclusive.

Mr. Wm. Sturgeon, a native of London, about the year 1825, discovered that when wires of soft iron were placed within the coil of a conducting wire, they were rendered intensely magnetic. (*Annals of Philos. Vol.* XII, *page* 359.)

Our knowledge of this subject was afterwards greatly extended during the period from 1828 to 1831, by the researches of Professor Henry, Secretary of the Smithsonian Institute, at Washington.

Though soft iron does not retain magnetism, its magnetic properties, while under the influence of a galvanic current, are very surprising. A piece of soft iron, about a foot long and an inch in diameter, is bent in the form of a horse shoe; an insulated copper wire is twisted round the bar at right angles to the axis, and an armature or keeper of soft iron, to which a weight may be attached, is fitted to its extremities. On connecting the ends of the wire with a simple galvanic circle, the soft iron instantly becomes a powerful magnet, and will support a weight of 50, 60, or even 70 pounds. As soon as the galvanic circuit is broken, the iron immediately loses its magnetism, and the weight drops. When the number of coils is increased they give great additional power. The wire used for making the helix must be wound with waxed or silk thread, to insulate it, so as to prevent the current from skipping along the contiguous parts of the coil, and thus taking a shorter route for its circuit, instead of traversing around the bar.

The instrument first used by Prof. Henry, in 1828, to illustrate electro-magnetic action, consisted of an iron bar, two inches square, twenty inches long, bent in a horse-shoe form, and weighing 21 pounds. The keeper weighed 7 pounds, and 540 feet of insulated copper wire, were wound in nine coils of 60 feet each around the horse-shoe shaped bar of soft iron. From the experiments which he made with it, he proved that a small battery is capable of producing great magnetic effects, if the spirals of the coil are numerous, and the resistance to the passage of electricity is not very great. He also showed the effect of varying the lengths of the conducting wires and the intensity of the current, and found that six short wires were more powerful than three of double the length. When the current was made to pass through all of the nine coils, the magnet raised 750 pounds.

After all his investigations, he concluded that we can use long or short wires as the case may require. Where we use long wires, the galvanic battery must have a number of plates, in order to give projectile force; on the contrary, a single pair of plates will answer for short wires.

"May it not also be a fact, that the galvanic fluid, in order to produce the greatest magnetic effects should move with a small velocity, and that in passing through one-fifth of a mile, its velocity is so retarded as to produce a greater magnetic action.

"But be this as it may, the fact that the magnetic action of a current from a trough is, at least, not sensibly diminished by passing through a long wire, is directly applicable to Wm. Barlow's project of forming an electro-magnetic telegraph, and also of material consequence in the construction of the galvanic coil. From these experiments it is evident, that in forming the coil we may either use one very long wire or several shorter ones, as the circumstances may require: in the first case, our galvanic combination must consist of a number of plates so as to give projectile force: in the second, it must be formed of a single pair.

"The wire used was 1060 feet (a little more than one-fifth of a mile) of copper wire, of the kind called bell wire, ·045 ($\frac{45}{1000}$) of an inch in diameter, were stretched several times across the large room of the Academy."—(*Silliman's Journal, Vol.* XIX. *January*, 1831.)

He afterwards endeavored to ascertain the best form of iron to receive magnetism, but did not succeed satisfactorily. However, he found that magnetic power resided wholly on the surface of iron bodies, though a certain thickness of metal is necessary for its complete development.—Hence the larger amount of iron surface we have, the more powerful will the magnet be, when all other things are alike. This is the reason that a bundle of wires will exhibit greater magnetic effects than a solid bar, containing much more iron. Bachhoffner of Germany, and Sturgeon of London, were the first who noticed this fact.

In 1830 Prof. Moll, of Utrecht, made some experiments of the same nature, and noticed particularly the sudden destruction and reproduction of magnetism when the current is reversed.—(*Bibliothéque Universelle*, 1830, *p.* 19.)

Subsequently, Prof. Henry constructed two of the largest and most powerful instruments of this kind at present known. One now in the cabinet of Yale College, weighing 59½ pounds, which sustained a weight of 2063 pounds; another, belonging to the cabinet of Princeton College, N. J., of 100 pounds weight, which could support 3500 pounds, or one and a half tons.

According to our present knowledge of the matter, the power of an electro-magnet depends on five important conditions, viz. 1st, The intensity and tension of the electric current. 2d, The number of coils around the magnet. 3d, The quantity of iron composing the magnet. 4th, The structure of the iron, the purest, softest, and most homogeneous receiving the most magnetism. 5th, The form of the magnet, as cylinders were found to support greater weights than solid bars, and bundles of wires more than cylinders.

To be Continued.

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*Causes and Prevention of the Explosion of Steam Boilers. Extracts from a Lecture delivered by* Dr. J. L. Smith, *before the New Orleans Lyceum. Communicated by the Author.* *

The explosion of boilers are devisable into two classes, namely, the simple bursting of the boiler when the plates are ruptured and opened by a steady pressure from within, and those explosions, the effects of which seem to exceed any thing that could be imagined would result from an accident of this character; this last has been properly called by the French *explosions fulminantes*. Not only is the boiler burst under these circumstances, but the whole or a part of it is projected with the rapidity and force of a rocket, and although weighing six or eight tons, may be thrown to a distance of many hundred feet from its original position, even when the rupture of the boiler is of small dimensions.

It will be remarked that in these cases the opening made in the boiler is always in the end opposite to the direction in which the boiler is thrown; in other words, it is projected by the reaction of the steam, which escapes against the air; and in fact, is subjected to precisely the same action as a rocket. No gradually increased pressure could cause a result of this description, and it is not so much an immense pressure that is required to pro-

* From the New Orleans Daily Crescent, February 24, 1851.

duce this as a very rapid development of that pressure. An iron bomb-shell, several inches in thickness, may be burst by two or three pounds of powder, although we might condense with safety into the same shell, fifty times the amount of gas formed by the combustion of the powder; the fact is, that although the powder does not form gas enough to explode even a much thinner shell, if the gas were gradually formed, still, in the actual state of things, its rapid development more than compensates for the want of quantity, and the effects produced are far more terrific than those which could be produced by a steady pressure, however great.

The same fact is still more remarkable with that class of bodies called fulminating powders, which, when exploded in small quantities in close vessels of great strength, will burst them with prodigious violence, even when the gas formed from the combustion of the powder would not more than fill the capacity of the vessel; this is owing entirely to the instantaneous production of the explosive force.

These remarks are merely to show the necessity of separating the study of the two classes of boiler explosions, the first of which arises from either deficiency in the strength of the boiler or from carelessly overburdening a boiler of proper strength (a too frequent occurrence.) The engines of most steamboats, when in proper motion, are said to exhaust the boiler three times in the course of a minute; so then, when the engine is stopped, this large amount of steam will accumulate in the boiler if proper care be not used to prevent it. The water in the boilers, when the boat is not in motion, and with the steady fires, will acquire fifty degrees of heat in two and a half minutes, and let us suppose that the pressure of the boiler is one hundred pounds per square inch; now, at the end of two and a half minutes stoppage, the pressure will have increased two hunhundred pounds, for it has been ascertained that an increase of fifty degrees of heat will double the pressure of the steam, and in two and a half minutes more, or five minutes from the stoppage, the steam will have accumulated to four hundred pounds pressure to the inch. Now, there is doubtless much carelessness in observing the boilers when a boat stops, and consequently the rapid accumulation of steam becomes a frequent cause of the first class of explosions.

The consideration of the more immediate causes of the second class of explosions, (*explosions fulminantes,*) are those which mostly excite our attention and for their explanation we have to search for some condition of the interior of boilers that will give rise to a rapid evolution of steam.

A cause very commonly admitted, and one in which there is, doubtless, great truth, is, that of the water getting below the fire line of the boilers, a considerable portion of the boiler becoming exposed to the fire without water being in contact with it, thereby getting greatly overheated and diminished in strength.

While the engine is at rest and the safety valve closed, the water remains quiescent under the accumulated pressure on its surface; the moment this pressure is diminished by working the engine or opening the safety valve, a frothing or boiling in the water takes place, its surface is raised and brought against the overheated sides of the boiler, an immense amount of steam is rapidly formed, and neither the safety valve nor the cylinders will allow a sufficiently rapid escape of steam, to prevent, in many instances, a terrific explosion; particularly when the boiler is already over-

charged by a steady pressure, weak in its natural construction, and the iron diminished in strength by the heat to which it is subjected. In the minds of most persons this is considered a frequent cause of this class of explosions.

It is insisted on by many, that accidents occur when the proper quantity of water is in the boiler, the boiler strong, and the pressure not beyond its normal condition. Now, it is asked how is it possible, under these circumstances, for one of these explosions to take place? In vain have explanations been sought after, and we either quit the subject in despair of finding out the cause, or in disbelieving that it can happen under those circumstances. I must, however, state, that after a very close examination of the subject, I see reason to believe that a rapid formation of steam may take place under the circumstances alluded to above, and explosions result.

In studying the causes of the explosion of boilers, it is usual to proceed by taking into consideration the ordinary properties of water, and the laws of liquids with reference to heat, presuming that we understand all the laws that water obeys in being heated from the freezing point to six hundred degrees or more. But the fact is, that as far as our knowledge goes, water does not obey a regular set of laws with reference to the action of heat upon it—in this respect it has many peculiarities.

Commencing with water at the ordinary temperature, and gradually abstracting heat from it, the water contracts, and continues to do so until it reaches forty degrees, when any diminution of temperature will cause it to expand until it reaches freezing point. Here, then, is a circumstance occurring in water contrary to what we knew of as belonging to other liquids, which contract by the abstraction of heat down to their freezing point. Again, it is usually considered that if any thing is fixed, it is, that water becomes solid when reduced to thirty-two degrees (its freezing point); yet, singular to say, this is not the case, for, under certain circumstances, (as that of perfect repose,) water may be reduced to a temperature ten or twelve degrees below the freezing point without becoming solid; this, then, is another peculiarity belonging to water that no other liquid we know of possesses.

If we consider the temperature at which water may be heated in the open air, without boiling, a third still more remarkable peculiarity will be seen. Nothing appears better settled, than that water boils at 212 degrees in open vessels, and that it cannot be heated beyond that; now it has been clearly proved, and the experiment lately repeated by Prof. Faraday at the Royal Institution, that water completely deprived of air, may be heated in an open vessel to 250 or 260 degrees without commencing to boil, but once the ebullition begins, steam is given off in an explosive manner, and all the heat that has accumulated between 212 and 260 degrees, enters instantly into the formation of steam, the water falls to 212 degrees, and the regular ebullition continues. Seeing then the existence of this latter peculiarity in water, what then is there irrational in supposing that water in a boiler may acquire a temperature beyond that due to the pressure of steam on the surface?

When the boiler is perfectly close, and the water heated, it does not boil, but gradually increases in temperature, a pressure of steam accumu-

lating above the surface of the water, just in proportion to the temperature of the water; and according to experiments made, water in a boiler at 300 degrees, ought to furnish a steam exerting a pressure of a little more than sixty pounds to the square inch. Suppose then a boiler to be in that condition, and the water should continue to acquire heat, without that heat converting any additional quantity of the water into steam; (a very rational supposition, when we see that water in an open vessel can, under certain conditions, be heated 40 or 50 degrees above 212 degrees, without the formation of steam;) and suppose the water arriving to 320 degrees, and the pressure of steam be at 60 pounds, which is 30 pounds lower than what is due to water at 320 degrees. Should now any disturbance of this state of things take place, either by the opening of the safety valve, or by the working of the engine, the water would evolve with prodigious rapidity an amount of steam due to this excess of 20 degrees, and we cannot properly estimate the rapidity with which this will take place, as every particle of water gives out almost at the same instant a portion of steam, and even this rapidly increased pressure of 30 pounds, might be sufficient to endanger the boiler.

Now, if it be possible for the water to acquire 40 or 50 degrees more temperature than it ought to have, in consideration of the pressure of the steam upon the surface, we would be liable at any moment to have the pressure on the boiler doubled almost instantaneously.

These, then, are indications that I advance, thinking them worthy the attention of those engaged in investigating the subject, and, may be, seeking for the cause of those explosions, when every thing connected with the boiler is apparently as it should be. This is one of those explanations that can only be properly determined by experiment.

There are many supposed causes of the explosion of boilers, that are sometimes insisted upon with a great deal of tenacity by their advocates. It is occasionally stated, when all other explanations fail to account for a particular explosion, that electricity had been the cause, without telling how this electricity could be formed, and when formed, how it could burst a boiler. Although it is possible to render a boiler, with steam escaping, electric, it must be insulated for this purpose either on glass rods or some other non-conductor of electricity. But in the case of boilers as they are constructed, this insulation does not exist; yet, if by any hazard a prodigious amount of electricity was accumulated in a boiler, from the known conductibility of metals, the electricity could be discharged from the boiler without disturbing the most delicate part of its structure. And, could we accumulate the electricity of a flash of lightning on a steam boiler, from the known relation of metals to electricity, it would be discharged with the same harmless result to the boiler.

Another cause, occasionally advanced, is, that the explosion of hydrogen gas has burst the boiler. This, however, is no more tenable than the cause of electricity; for we must first learn how this gas is formed, and once formed, how it can produce an explosion. Direct experiments have been made by evaporating water to dryness in a boiler, and examining from time to time the steam, without finding any hydrogen gas mixed with it. In order to form hydrogen from the water, or vapor of water in the boiler, it is necessary that the sides of the boiler should be at a red

heat, a temperature at which the iron is diminished to one-sixth its original strength, and it is therefore presumable, before this state of things could occur, the integrity of the boiler would be injured by the ordinary pressure of steam. But suppose that the hydrogen be formed by the decomposition of the vapor of water, against the red hot sides of the boiler, that the iron combines with the oxygen of the water and liberates the hydrogen, how is this to explode? for hydrogen gas is inexplosive; it is a mixture of hydrogen and oxygen gas that is explosive, not pure hydrogen gas; and as there is no way that we can possibly divine, by which the hydrogen could be furnished with oxygen, this hydrogen explanation for the explosion of boilers becomes groundless.

There is yet another explanation, more commonly regarded as a cause of explosion than either of the last two; it is, the injection of cold water into an over-heated boiler that has been exhausted of its water. It is the opinion of those who have investigated this experimentally, that no danger can arise from letting cold water into a hot boiler; and among those whose investigations have led them to adopt this conclusion, are Mr. C. Evans, of Pittsburgh, and a committee of gentlemen at the North, now engaged in investigating the subject of the explosion of boilers.

Mr. Stillman, of the firm of Stillman & Allen, Engine Makers, New York, on one occasion, seeing the engine of the shop stop without any apparent cause, on examination found that all the water was out of the boiler, and the flues very hot; he immediately turned the cold water on, and as the water entered the boiler, he could trace its elevation by looking into the flues, and see them gradually cooled down. This experiment might appear dangerous to some, but upon a little reflection, I have no doubt it would seem a harmless one. Boiling water admitted under the same circumstances, might be dangerous.

An explanation has been attempted to account for the explosion of boilers by Mr. Boutigny, of France, which involves a peculiar condition of water on hot surface; it has, however, not sufficient practical bearing to be insisted upon here.

So, from what has been stated in this lecture, the immediate causes of the explosion of boilers are reducible to two. An immense steadily increased pressure, producing the bursting of boilers properly speaking—and a rapid formation of a large amount of steam, productive of explosions; and the manner in which these conditions were probably brought about, have been mentioned in full.

It is not sufficient that we should know the cause of these accidents, but it is equally important to seek after the manner of remedying them.

First of all, the frequency of these accidents would be most wonderfully diminished could the use of high pressure steam be done away with, and low pressure boats be substituted. Doubtless, the ingenuity of our mechanics could devise some system of low pressure boat adapted to these waters, if steamboat proprietors would be willing to enter into so great a reform.

Again, high pressure engines could be made to work with a lower pressure than is now used, which might be done, and their power rated lower; as it is, the pressure used in steam boats on the western waters surpasses every thing that is dreamed of in other parts of the world, ex-

cept on locomotives, whose boilers far exceed in strength every other description.

As regards the construction of the boilers, I would merely state that the ties used to strengthen the boiler can not be too many, and that they ought not to be fastened directly to the plates of the boiler, but wherever they are riveted on, an iron band should go around the boiler, and the rivets pass through the boiler plate and the bands; this would doubtless give great additional strength to the boiler.

The safety valves should be larger or more numerous, to give sufficient vent to any sudden formation of steam. Some contrivance should be used to prevent the boiler from being overheated, and there is none better than the plugs of fusible metal placed in that part of the boiler immediately over the fire, which, on the water arriving at too high a temperature, would melt, and let the water out upon the fire. There is yet another method that has been devised for this purpose, that was proposed some years ago by Dr. Riddell, and has since been made the subject of a patent by some one else. It is based upon the difference of the expansion of copper and iron by heat. A copper rod, nearly the length of the boiler, is fastened in one end of it, and the other end is attached to a valve which slides over an opening on the bottom of the boiler; now this rod lies immersed in the water, and as the boiler and water become heated, the boiler and the copper rod both expand, but the copper rod expands more for the same amount of heat than the iron does, the consequence is, that the valve on the bottom of the boiler is moved; there is nothing easier than to so arrange the position of that valve with reference to the opening in the boiler, that when the water, and consequently the rod, are heated to a certain temperature, the valve will uncover the opening and let out a portion of water upon the fire, which being partly extinguished, will permit the boiler to cool, the rod to contract, and the opening be again covered up. This method could no doubt be rendered practical, although I am not aware of its having had any application.

The next most important step to take in this matter is that by legislation; for, let the ingenious invent what remedies they please, to prevent the explosion of boilers, there are always a number of the reckless and indifferent who will not adopt them, and even neglect the ordinary precautions of safety. In this place a boiler explosion takes place—forty or fifty lives are destroyed—a kind of investigation is made, which generally results in finding out nothing as to the cause of the explosion, and exonerating all those responsible in the matter. This is not owing to any deficiency of will or zeal on the part of those whose business it is to investigate it, but from want of a proper method as well as judicious laws to enforce the results of their investigation.

Why not, as in other countries, make it criminal to carry over a certain pressure of steam? for most surely it is criminal to jeopard the lives of those who entrust themselves to your care. Certainly there is no more wholesale species of manslaughter than that which results from many of the explosions occurring on these waters, and there is no body of men more responsible for it than the Legislature of the various States, for it is in their power to diminish the frequency of them.

Let them, as I before said, enact laws making it criminal to carry over

a certain pressure of steam; make it necessary to have a safety valve enclosed beyond the reach of any one on board of the boat; make it punishable to insert any thing but fusible metal in the holes of the boiler meant for that purpose. The Legislatures of the various Western States should also make a joint appropriation of some twenty or thirty thousand dollars, to investigate the explosion of high pressure boilers, not by experiments made on small apparatus, but on boilers of the dimensions ordinarily in use. And if these means be resorted to, the columns of our papers will not be daily filled with those lamentable boiler explosions which have become a reproach to the steam engine on these waters, and are considered in other parts of the world as discreditable to a nation that has such just cause to boast of its rapid strides in civilization, arts, and science.

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*Remarks.*—We insert the above lecture with great pleasure, not because we agree with all the views of the author, or with his suggested explanation of the "*explosions fulminantes*," but because it contains a great deal of common sense, and the results of reading, observation, and accurate thought, and calls attention to what is in reality a disgrace to our country. In regard to the cause of these explosions, we have ourselves never yet met a case where there was not reason to suspect one of the causes first mentioned by him, viz.: either deficient strength of the boiler, gradual increase of the steam pressure above the power of resistance of the boiler, or the sudden increase due to water being suffered to come in contact with overheated iron. As it regards the bearing of Faraday's experiments, to which the lecturer alludes, we think that if he will read them again attentively, he will find them as inapplicable to the case of steam boilers, as the spheroidal state of the water proposed by Boutigny. For the phenomenon depends on the perfect stillness of the water, requires that the surface of the vessels should be very smooth, the water free from air (which is never the case in practice,) and the vessels comparatively deep and not too large, (a common glass test tube will show the experiment very satisfactorily, as many an unfortunate chemist who has been manipulating in too much of a hurry can tell.) The shaking of a steamboat or locomotive boiler, the deposit of insoluble matters, or the rough surface of the inside of a boiler in use, by giving rise to an evolution of steam, would always in practice prevent the phenomenon, though we suppose that in stationary boilers with hanging tubes, such as the one recorded in Vol. XVI, page 140, of our Journal, the case might occur. (That it did not in that case, is shewn by the fact, that the explosion took place on the reduction of the temperature.) We would also call the attention of Dr. Smith to the fact, that this sudden evolution of steam may take place and the boiler be projected, even where the first rent is produced by the simple yielding of the material. Such appears to have been the case of the explosion of the boiler at Mr. Greble's marble yard in our city, and it is very probable, that such a state of things caused the dreadful explosion of the locomotive Neversink, on the Reading Railroad. (Journal, Vol. XIII, page 331.)

We are very glad to find the author replying so judiciously and satisfactorily to the hydrogen and electrical theories of explosion, which are so entirely absurd, and so constantly evoked to shield those responsible

from the just consequences; and we like his suggestion of banding the boilers at the lines of stays; but we must remind him that the fusible plugs have not been found to answer as well as was expected, nor do we believe that when the boilers are properly made and tested, and confided to careful and competent engine men, the employment of high steam is any more dangerous than that of low.

We are, moreover, much surprised to hear a gentleman evidently so well informed on the subject, sanction the opinion of the harmlessness of injecting cold water into an overheated boiler, when not only experiment, but experience teaches us every day the contrary. It is true, that such an experiment as that attributed to Mr. Stillman may for once succeed, but the chances are indefinitely great in favor of an explosion, and had such occurred, mere justice to the sufferers would require severe punishment on any one who would direct it. What difference in practice can exist between putting the water in hot or cold, we cannot see, for the surplus heat contained in water at 212°, compared with that at 32°, is but a trifle compared with the amount consumed by the conversion into steam.

In reference to the matter of legislation, we have never omitted an opportunity of calling the attention of our readers to the necessity of our imitating other nations in their excellencies, (as we do in their follies,) and holding the negligent managers of exploding boilers strictly responsible for the consequences of their inattention. For the two last sessions of our Legislature, a memorial from the Committee of Science and the Arts of the Franklin Institute has been before it, praying for the adoption of a system of rigid examination of boilers, and of explosions; but that respectable body is so occupied with political manœuvring, that they have no time to attend to the welfare of their constituents. We hope that sometime or other a better time will come. Ed.

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For the Journal of the Franklin Institute.

## *The Collins' Line of Steamships.*

About a year has elapsed since this line commenced their trips across the Atlantic, and already enough has been demonstrated to prove them as unsurpassed in speed, as it has been universally conceded, they are unequalled in model, and for the beauty and convenience of their internal arrangements. Enough at any rate is already known, to justify me in drawing your attention to the many unfair and injurious reports that have been brought to bear against them, and principally, I regret to say, on this side of the Atlantic; for strange as it may appear, more open and concealed enemies to the line, have existed among us than in England, taking the published statements as the standard by which to judge. It is my present purpose fairly to state the case, and to show, as I think conclusively, that the steamers of this line are a triumph to our skill, and a credit to those who designed and constructed them. These vessels were commenced just after the appearance of the Europa, Canada, Niagara, and America, and were intended to surpass them in size and speed. But as soon as these ships were fairly commenced, the Asia and Africa, larger and more powerful than the former steamers of the line, were put under contract, and by great exertions, brought out nearly at the same time as the steamers of this line, so that to achieve a name, we had not only to

do all that our vessels were intended to do, but to excel the last two steamers also. How well they have accomplished their object, the public can determine; but they, looking only at the shortness of the passage without regard to circumstances, are unable to understand the real value of our success, which is the point to which I wish particularly to call your attention.

The dimensions of the contending vessels are as follows:

| | Atlantic, | Pacific, | Baltic, | Asia. |
|---|---|---|---|---|
| Length on Deck, | 285 feet. | 284 feet. | 287 feet. | 280 feet. |
| Breadth of Beam, | 45½ " | 45 " | 45 " | 40 " |
| Depth of Hold, | 32 " | 32 " | 32 " | 27½ " |
| Tonnage, (Custom House,) | 2771 " | 2686 " | 2718 " | 2072 " |
| " (Carpenter's,) | 3040 " | 2900 " | 2920 " | 2240 " |
| Load Draft, | 20 " | 20 " | 20 " | 20 " |
| Diameter of Cylinders, | 95 inches. | 95 inches. | 95 inches. | 96 in's |
| Length of Stroke, | 9 feet. | 9 feet. | 10 feet. | 9 feet. |
| Nominal Horse Power of both Engines, | 800 H. P. | 800 H. P. | 828 H. P. | 816 " |
| Diameter of Paddle Wheels, | 35 feet. | 36 feet. | 36 feet. | 36 feet. |
| Length of Paddles, | 12½ " | 11½ " | 11½ " | 9½ " |
| Immersed Midship Section, | 725 " | 720 " | 720 " | 640 " |

The term nominal horse power, has become a mere conventional unit for expressing a certain size of cylinder, without reference to the power exerted; and the *actual* horse power exerted by the engines of either American or English steamers greatly exceeds the nominal. This may be attributed to the increased pressure of steam used since the rules for calculating nominal horse power were established by Watt. In England, they designate the size of their cylinders by horse power, a term rarely alluded to in this country among engineers, who always speak of the diameter of the cylinder and stroke of the piston. From an examination of the above table, it will be seen that the Asia has cylinders one inch larger than the Atlantic or Pacific, and the same length of stroke; estimating the nominal horse power by rules established in England, the power of the Asia = 816, and the Atlantic and Pacific 800, as will readily be seen from the following rules:

1st, The square of the diameter of the cylinder in inches, multiplied by the cube root of the stroke in feet, and divided by 47 = nominal horse power, thus,

$$\frac{95^2 \times \sqrt[3]{9}}{47} = 800 \text{ horse power.}$$

It is quite a mistake to suppose that the new steamers of the Cunard Line carry but 7 lbs. of steam; the average pressure is about 13 lbs., while that of our steamers is about 15 lbs.; and when you take into consideration that our vessels cut off the admission of steam into the cylinder at ⅓ the stroke, and that *they* generally use it to a much longer point, it will be apparent that the actual horse power developed, will be the greatest on their steamers.

From the statistics given, we find that the immersed midship section of the Asia is 80 square feet less than the Pacific or Baltic, and 85 square feet less than the Atlantic, giving per square foot of immersed section to the

Atlantic, 1·10 H. P. Pacific, 1·12 H. P.
Baltic, 1·16 " Asia, 1·28 "

the Asia having an important advantage over either of the others.

Having demonstrated that the Asia has less immersed midship section and greater power, the question may properly be asked, how can the Pacific and Atlantic equal in speed the Asia? I answer, by superior model, which at high speed, gives us decided advantage over them in that particular. As a proof of this, I would state that the new Cunard steamers now building, (the Arabia and Persia,) will resemble them in model, and will also have tubular boilers. In one respect, however, they have always had a decided advantage; their firemen and engineers have been long in the trade, are accustomed to its severe duties, and are perfect in their parts; while with us, great changes have taken place, and the ship often goes to sea with one-half at least new hands in the engineer's department. Until we have full crews well accustomed to their several duties, we shall suffer materially. In this respect, I am happy to state that a great improvement has taken place within the past few months, and I trust that soon we shall have the advantage of picked crews, to contend with our friends across the Atlantic. For it is evident that they are not to be beaten from the want on their part of their best exertions to prevent it. It must not be forgotten, that the Asia is 600 tons less burthen than the ships of this line, consequently, has less accommodations for both passengers and freight.

Having shewn, as I think, that we have accomplished much, and that we have already surpassed our opponents in speed as well as in the comfort and convenience of our ships, I wish to show that we have had more opposition to contend with at home than abroad; there they have done us the justice to say, that the ships of this line were a credit to the country; while among us, no sooner was the Atlantic finished, than the most exaggerated accounts were given of the vessel, by ill advised, would-be-friends; her size was stated to be 3000 to 3500 tons, with engines of 1000 horse power each, and much else having about the same relation to the truth.

On her first passage out, she had the misfortune to break her air pump bucket, which caused a detention of 30 hours; when immediately the same parties that had played at bragg, shook their heads wisely, and intimated that proper attention had not been paid to their machinery, and so it has been ever since.

The Pacific was laid up a few weeks last winter to do some repairs to her boilers and machinery, and put a new saloon on deck, and it was immediately announced that a new bed plate was to be put under one engine, at a cost of $20,000. To be sure, the story was contradicted the next day, but if the truth only had been uttered, no contradiction would have been needed. So when the Atlantic broke her shaft, not satisfied to wait a reasonable time for information, one party very wisely hints, that possibly the boilers have exploded, or some other accident, *serious* in its nature, has occurred, and that it is strange we cannot build machinery with the English. If the Cunard steamers are behind time, the wind must be ahead; but if these ships are the same, some accident has happened to their machinery.

I very much question if these same parties can call to mind a single accident that has happened to the Cunard line. The chances are, they would *deny* that one ever did happen, and if you should state that one had broken a shaft, and only made the passage this way as far as Halifax, and

sent her passengers to Boston by another steamer; that another had been lost on the coast of Maine; and that about a year since, on a passage this way, one of them broke a side lever, causing much injury to and rendering one engine entirely useless, and that she left on her return trip with but one engine, and took her usual number of passengers, he would deny the whole, although perfectly true. There is another class of friends, who think these steamers can be very much improved, and have published *their opinions* in relation thereto. One who must think himself a paragon of wisdom, states that the machinery of the Baltic weighs 1800 tons, (its real weight is 825;) that to ensure a safe passage, she should carry 1800 tons of coal, (her bunkers hold but 1050, which usually leaves 2 or 3 days' supply on hand;) and that she should have 60 feet wheels. With these improvements, he promises increased speed, although all his suggestions have not a grain of common sense in them.

And here let me notice an article in *Appleton's Mechanics' Magazine* for March, by B. F. Isherwood, Chief Engineer, U. S. N., who compares the Pacific, (the clipper of the sea,) with the English war steamer, Arrogant, a propeller. You might as well compare the *American Eclipse with a Donkey.* There is great injury done by suggesting the possibility of comparison; one has crossed the Atlantic at a speed of 13 sea miles, while the very best speed of the other, with sails and steam, is about 9. But see how the comparison is made, and that, too, by an American. He states, page 153, that the Arrogant is 200 feet long between perpendiculars, *and that the Pacific has almost the identical dimensions of the Arrogant, and is* 210 *feet between the same points;* he also says, he is *fortunately* in possession of the exact data of the two vessels, while he has hardly a single item right; but, leaving the small errors to take care of themselves, I will state what will considerably affect this *exact* data. The Pacific is 271 feet between perpendiculars, and 284 feet on deck, a small difference of 61 feet in length, or nearly 30 per cent. If the hulls are exact with this difference, we must yield the point. Mr. I. says, the Arrogant made 8·35 miles per hour in the river, and that the Pacific made 12 miles. Now the latter can go, in the river, 15 miles per hour with the greatest ease, and has done it often. I have no disposition to follow this gentleman further, but I think I am not going too far, when I say it becomes all who write for scientific Journals, to pay some regard to facts—we do not look for romance here, or at least, not such a one as the comparison of the Arrogant and Pacific. As an American engineer, I feel proud of the success of the Cunard steamers; for about twelve years they have crossed the Ocean with great success and with a constantly increasing speed, as each addition was made to the line. There is no reason for envy, for the world is large enough for us both, and neither can make an improvement which does not in some degree benefit the other; and while I am pleased with their success, I may be still more so at our own, and may rejoice that we have at length become the *master* of the *mistress* of the seas.

PRACTICE.

For the Journal of the Franklin Institute.

## *Steamer Monumental City.*

In the description and report upon the performance of the steamer Monumental City, published over the signature of I. in the December number of the *Journal of the Franklin Institute* for 1850, we have discovered several errors and inconsistencies affecting the character and performance of the machinery, to which we beg to call the attention of the readers of the Journal, and make some reply.

The description of the ship and machinery is, with slight exception, correct, and was it not that exactness in all such matters is of much importance, we should not deem it necessary to notice so slight a discrepancy as exists in this instance. The only error in this connexion, consists in stating that the stuffing boxes for piston rod, are of "*the usual dimensions for engines of stationary cylinders*," which, if our knowledge as to the general practice be correct, is not the fact; the diameter of the stuffing boxes, being such as to accommodate a rod of six inches diameter, and their total depth eighteen inches, when the glands are screwed hard down, which we think somewhat larger than the dimensions usual in engines having cylinders (fixed) of but 44 inches diameter.

In this connexion, we would add, that the glands are of greater depth than usual in engines with fixed cylinders, and are bushed with brass, and that a bushing or gland of brass of some six inches in depth is fixed in the bottom of each of the stuffing boxes also.

In regard to the *performance*, there are several errors and discrepancies of more serious import, growing out of the circumstance, doubtless, that I. was not a witness to all the facts reported, and was, without doubt, wrongly informed as to some of his distances.

The first error under this head, which we shall notice, is in the distance from the Lazaretto Lighthouse to the Fort, or Soller's (Teller's) Flats, stated to be 4 miles per U. S. Coast Survey. This we believe to be incorrect for the following reasons:

*First.*—Because of the fact, that a reference to a recently published map from the Coast Survey Office, which defines the positions of the two points (Hawkins' and Soller's) on either side, but within the location of the new Fort, not, however, of the fort itself; and carefully measuring the distance by scale upon the track taken by the ship, from a point opposite to the Lazaretto Lighthouse, to a point abreast of the supposed location of the new Fort, we find the distance to be about five miles.

*Second.*—Because of the fact, that but few of our best side-wheel, light draft passenger boats, run the distance between these two points in less than *twenty minutes;* which, allowing these boats to average but 15 miles per hour, would make the distance at least 5 miles; and,

*Third.*—Because of the fact, that the statement made in regard to the run made on the 17th day of November, from Cove Point to the Bodkin Lighthouse, (though not so favorable to the ship as it should have been, as we shall hereafter show,) against a head wind amounting almost to a gale, and an ebb tide, which, when accompanied by such a wind as that blowing at the time, caused a very considerable adverse current, shows a

much less degree of slip than that estimated from the run between the Lazaretto and Fort.

The next and last of the errors to which we shall call attention at present, is that in regard to the run from Cove Point to the Bodkin Light-house. In this case the *aggregate time consumed* between the two points mentioned, as well as the *actual* distance, are correct as stated. But the numbers given as the average of revolutions of the screw and engines, and pressure of steam in the boilers, we think not so.

The writer of this was on board during this run, and watched with much care, the performance of the engine, and does not remember any period, except perhaps for a few minutes, when the speed of the engines exceeded 38 revolutions per minute, and feels confident in the expression of the opinion, that they did not reach this number during more than one-fourth of the time occupied between these points; and that they several times fell, and for a considerable period kept below 30 revolutions per minute.

As to the average pressure of steam reported, we would remark, that for a considerable portion of the time, owing to want of experience and attention on the part of the firemen, the steam was suffered to fall much below *five* pounds per square inch, and but once, and then only for a few minutes, did it exceed a pressure of 16 pounds.

Furthermore, the furnaces of one of the boilers were suffered to become so foul, as in the opinion of the engineer in charge of the engines at the time, to render the entire withdrawal and renewal of the fires in them, absolutely necessary, which of course occupied much time. And besides this, several stoppages became necessary to afford an opportunity to free the water valves attached to the cylinders of chips, &c; which, from time to time, would find their way through the steam openings into the cylinder, and were forced by the pistons into these valves. Some distance and time also was lost, by being driven from the proper course by the wind.

In conclusion, assuming the distance between the Lazaretto Lighthouse and the Fort on Soller's Flats, to be 5 miles, the average number of revolutions, 42 per minute, and the time, 32 minutes, as stated by I., the slip would be $21\frac{4}{10}$ instead of $37\frac{1}{4}$ per cent., as estimated by him, which is still thought to be excessive; in support of which we would remark, that frequent and careful observations of the distance passed over between the successive jets of water thrown out by the air pump (the discharge being just above the water line,) when running in smooth water, indicated a slip not exceeding 10 per cent. M. & H.

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For the Journal of the Franklin Institute.

## *Marine Steamers.*

The recent introduction of the ordinary beam engine of our river boats into several sea steamers of magnitude, has been so far attended with complete success. The Prometheus recently performed the passage from New Orleans to New York in $6\frac{1}{2}$ days, being the quickest passage ever made; and since that time the North America has made a quick run home from Chagres. Within a few months past the following steamers have been finished, having sea-hulls and river beam engines of extra strength: the Pacific, (for the Pacific trade,) the Prometheus, North

America, El Dorado, and Brother Jonathan. The last three intended for the trade from New York to New Orleans and Chagres. The objection urged against this form of engine has been, that it elevates the centre of gravity of the machinery—the tendency of which is to destroy the stability of the hull. This is true; but when we reflect that the boilers, shafts, and wheels, channel plate, condenser, air and force pumps, all retain the position they would have with the side lever engine, and that the only portion that is much elevated is the beam with its connexions, and compare these parts with the size of the hull, we shall find that the elevation of one piece of machinery of 10 tons weight, 12 to 15 feet above the deck, will not have the effect that was expected. So far it has not been proved in practice to be injurious. The advantages of this form of engine are less weight, less cost, and greater simplicity; in addition to this, they are slightly more economical. B.

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For the Journal of the Franklin Institute.

### *Oscillating Engines.*

Economy of space and weight is a very important item to be considered in the construction of marine steamers; and it is when viewed in this light that oscillating engines will be found to have many advantages. The steamship Republic, built at Baltimore, by Murry & Hazlehurst, was the first vessel of that class in this country having engines of this description. Her cylinders were 54 inches diameter, 6 feet stroke, attached to side wheels; and the space occupied by the engines was but 20 feet in width by 10 feet in length of the vessel. These gentlemen subsequently applied a pair of engines of the same kind, having cylinders 44 inches diameter, 3 feet stroke, to a 12 feet propeller, in the steamer Monumental City.

In this City, Messrs. J. T. Sutton & Co. have applied to the steamer Colonel Fremont a pair of engines of this description, with cylinders 40 inches diameter, 28 inches stroke, geared to a propeller; and for the steamer Albatross, a pair 40 inches diameter, 40 inches stroke, geared to a 10 feet propeller, the latter making $1\frac{3}{4}$ revolutions to 1 of the former.

In New York they are building at the Novelty Works a pair of engines of this description, with cylinders 85 inches diameter, and 9 feet stroke, to be attached to side wheels; and at the Allaire Works a pair of equal size. These engines are believed to be the largest of their kind ever built, and are to be used in the Pacific steamers of Howland, Aspinwall & Co.

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### *The Steamship Lafayette.*

This fine steamer, just completed in New York, has been added to the merchant marine of this city, and left on her first trip, May 7, 1851. Her dimensions are as follows:—Length of keel, 200 feet; breadth of beam, 33 feet; depth of hold, 27 feet. She has three decks, the upper being devoted to passengers, and the rest to machinery, coal bunker, and freight. Her hull was constructed by Perrine, Patterson & Co., of Williamsburgh, and has the appearance of good workmanship, combined with

beauty of model. The machinery was constructed by Hogg and Delamater, of New York, who have been for several years accustomed to the construction of machinery for screw steamers, and this job has the appearance of strength without any extra finish. The engines are direct action cylinders over cranks, and connected at right angles; diameter of cylinders, 50 inches; stroke, 44 inches; she has a four bladed propeller, 14½ feet diameter, and two of Montgomery's vertical tubular boilers, with fan blast under grate, and uses anthracite coal. Her trips will probably be made in the time of the City of Glasgow. B.

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*Quick Passage of the Steamer Pacific from Liverpool.*

The Mail Steamer Pacific recently made the passage from Liverpool to New York, (dock to dock,) in 9 days and 20 hours. Her rate of steaming may be seen from the following table:

| | | | |
|---|---|---|---|
| April 10, | 22 hours, | 278 miles. | |
| " 11, | 24 " | 308 " | |
| " 12, | 24 " | 310 " | |
| " 13, | 24 " | 306 " | |
| " 14, | 24 " | 328 " | |
| " 15, | 24 " | 318 " | |
| " 16, | 24 " | 316 " | |
| " 17, | 24 " | 310 " | |
| " 18, | 24 " | 302 " | |
| " 19, | 20 " | 279 " | to Sandy Hook. |

This is the quickest passage ever made, as will be seen from the annexed table:

| | | | |
|---|---|---|---|
| Europa, Oct., 1849, | 11 days, | 2 hours, | 30 minutes. |
| Atlantic, June, 1850, | 11 " | 4 " | 30 " |
| Europa, July, " | 11 " | 7 " | 30 " |
| Atlantic, " " | 10 " | 16 " | 00 " |
| Pacific, Aug. " | 11 " | 7 " | 00 " |
| Atlantic, Sept. " | 11 " | 2 " | 00 " |
| Asia, " " | 10 " | 22 " | 30 " |
| Pacific, " " | 10 " | 4 " | 45 " |
| Asia, Oct., " | 10 " | 22 " | 00 " |
| Pacific, " " | 11 " | 3 " | 30 " |
| do. April, 1851, | 9 " | 20 " | 00 " |

Our friend John Bull must try again, or he is beat. B.

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*Waste Gases from the Blast Furnace. By* DAVID MUSHET, ESQ.*

Continued from page 327.

Take, for example, a furnace, 8 feet across the top, filled through a tube 8 feet deep. Diminish the diameter of the tube to 4 feet, and fil *only* coke into it. The flanch covering the annular space will then be 2 feet wide. In this flanch we have (say) six openings, secured with sliding covers, to be made air-tight by the means already used for that purpose. Into these openings *fill all the ore.* To give free vent for the gas, I would carry the conducting tube round the furnace—the top flush

*From the London Mining Journal, No. 809.

with the top of the filling place, and have six flues or openings into it, underneath the whole parts of the flanch. If these flues were each 3 feet square, their joint area would be rather more than the area of an 8 feet circle. I have understood the ordinary size of the conducting tube is 3 feet square. This cannot be large enough to give a free vent, let the draft of the boiler chimney be ever so great. As it is evident the opening of the slides to fill the mine would stop the abduction of the gas, and admit air into the annular space, three or six partitions of iron-plate must pass from the under side of the flanch, abutting from the wall to the tube, and of the same depth of 8 feet. Six partitions would be the safest and most complete. These would divide the annular space into as many compartments. Each of these would be filled separately and successively; and a slide door or damper, being dropped down into the corresponding flue before the filling cover was removed, the access of air to the main tube would be cut off, and *five-sixths* of the annular compartments would continue delivering gas. The damper being down, and the chain for raising it unhooked, when the filling barrow came forward, there would be no obstruction on the floor. If each filling orifice were provided with a hopper, and the charge filled into it, before the slide cover were wi hdrawn, there would be the least possible access of atmosphere—the cover being thrust to the moment the hopper had voided itself; but this might be quite an unnecessary nicety, because the flue being stopped, there would be a strong efflux of gas outwards. If this mode of filling be adopted, I would stake the existence of your valuable Journal (were it in my power) against the possibility of any difficulty on the score of scaffolding continuing to exist. A pillar of coke of concentrated heat will always be descending into the hearth, radiating in even circles towards the sides the proper degrees of cementation and deoxidation, and melting instantaneously in the fusing region the prepared materials which approach within its circumference. The gases in the annular space will *pass through the whole body of mine* before they make their exit to the boilers, imparting that *gradual increase* of temperature to the ore as it descends, which appears to be a point of great importance to the abstraction of oxygen. The surface of the materials at the sides of the furnace, instead of being constantly 10 feet at least, with an 8 feet tube, below the level of the filling place, will be only *three*, reckoning on the filling being kept flush with the bottom of the gas flues. The surface for collecting gas will be increased by 33 circular feet, in addition to what previously existed, according to the taper of the walls, on a level with the bottom of the tube. The whole annular space will be amply sufficient to receive the mine and flux, and the central tube, when the surface has sunk 4 feet, will be capable of receiving more than a ton of coke. An orifice in the cover of the tube, at least a foot in diameter, would be very advisable, to aid in preserving the central upward ascent, and to counteract the lateral tendency of the main channel of escape. This, of course, would be so much lost; but the main object is to have not *all*, but all that we can get *with economy;* but if there is *exhaustion* at work drawing off the gas to the boilers, it is plain no such aperture can be allowed. In this case, it would be advisable to erect the apparatus *over* the furnace—that is to say, when the height of

the furnace for maximum effect has been ascertained, let the tube and its appendages be applied on the top of that level. If so much as 8 feet were inconvenient, 4 feet might be within, and 4 feet above, the previous filling level. To avoid any jamming of coke in the tube, though I do not apprehend there are actually any ill consequences arising from that, nothing is easier than to give it a slight taper, by a few inches extra width at the base. The purest gas, most free from carbonic acid, would evidently in the above arrangement be obtained from the tube itself. This would require quite different contrivances to secure an unremitting supply for the boilers during the filling. I have views on this point which would comprise a method for giving a more intense heating effect to the gas when delivered for combustion; but as their perfection depends upon exact information, which I do not possess, as to the inflammability of the gases at different temperatures, from 60° upwards, I will not mix uncertain matter in this letter, to divert attention from arrangements—the practical effects of which by experience I can confidently predict; but generally I would again remark on the importance of not obstructing the vent of the blast at top. This will be sure in itself to cause a diminution of make and waste of fuel, be the other arrangements ever so perfect. As the covering over the top of the furnace confines much heat, which otherwise escapes by radiation, and prevents any waste of material by exposure to the air, it would be quite practicable and consistent to make the top of a furnace from which gas is to be taken double the area which would otherwise be given to it. This would obviate a part of the obstruction; and in apportioning the spaces, I would increase the annular space in much greater degree than the diameter of the tube which is to receive the coke. Many doubts and objections to this mode of filling will arise in the minds of those who have not before considered it; but I will answer them all in brief—*try it*. When I was weary of combatting every possible species of objection, I *tried it*, and the result even exceeded my expectations. It is well known the mine finds its way down much faster than the coke, and very much so in proportion as it is rich. It must be remembered that the heat in the upper regions of the furnace is not generated *there* by *combustion*. The ore does not require the coke to touch it to keep it warm. The heating influence is the passage of hot gas, which is generated by combustion within a very short distance from the tuyeres. This hot gas, which is the deoxidizing agent, being once generated, expands through every region of the furnace; and it is not of the least consequence if there be not an ounce of coke to be found within three feet of the walls of the upper part of the furnace, so long as the hearth is full, to generate the vital circulating current. But even this denudation of coke will not ensue. The coke will spread outwardly, and the heavy mine fall through it inwardly, until they reach the widest part of the furnace, where the complete action towards the centre begins, uninfluenced by the *opposite* outward action, which belongs to the *entering materials*. In the uniform descent from the sides to the centre, as exhibited in the sand glass, the heavy always tends to outrun the light—the mine to pass the coke. It is to keep the ore back from fusing too soon that furnaces are carried to such a height; and the annular plan of filling carries out and assists the same principle *horizontally*, which is

acted upon *vertically*. The more the ore can be retarded, until the fusing vacuity is made, into which it *must* fall, the more complete, uniform, and certain will be the whole operation of smelting, *with the smallest expenditure of coke*. This mode of filling, carried to the greatest extreme, would, I am confident, be most beneficial where the material is a heavy iron sand—such as the Wootz ore of Porto Novo. The extreme and troublesome rapidity with which this ore came down into the hearth was, I cannot have the least doubt, a main cause of irregularity of quality in the product. It engendered by necessity a crude digestion; and I can state certainly that the neglect of this mode of filling has generally been one cause of the difficulty of smelting rich ores.

I am gratified to see that M. Levi has renewed his valuable communications. The investigation of the real merits of the prejudice in favor of the use of limestone, has long been a desideratum, which I have myself looked forward to undertaking at a convenient opportunity. Some of the inferences in the present paper, I rather demur to. For instance, the conversion of carbonic acid into carbonic oxide can *in itself* be no disadvantage, but quite the contrary, by perfecting the deoxidating medium. The real cause of loss must be the absorption of heat entailed by that chemical change, and, as M. Ebelmen points out, by the vaporization of the carbonic acid. However, to appreciate justly M. Levi's details, it would be very important to know what circumstances led to the use of so lofty a furnace as 54 feet, the highest I ever knew in permanent work, and also its other proportions. One advantage I have looked forward to in the use of caustic lime is, a degree of diminution in the weight crushing on the coke.

P. S.—Since writing the above, I perceive that a patentee in this matter (Mr. Palmer Budd) ignores the existence of the alleged evils at works with which he is acquainted. Nothing is more probable than that they do not occur with certain materials. The lumps of Welsh ironstone, as they are used, may keep the furnace regularly open in whatever way they are put in, and carry off besides the obstruction of a large quantity of red ore. The Scotch blackband enjoys fully equal facilities, but there *are* materials which will not brook such free and easy treatment; and it must be with such troublesome subjects that those effects must have been experienced, which, whilst they are strictly consistent with principle, we cannot suppose would have been narrated in the *Journal of the Franklin Institute* without a foundation in fact. Besides the foregoing consideration of size, it is obvious what different consequences must ensue from stowing under the hatches of the gas apparatus an ironstone porous from calcination, and a raw hydrated ore, combined with 10 or 15 per cent. of water. The increase of make stated by Mr. Budd, I can only explain by the existence of an exhaustive arrangement, which diminishes resistance to the ascent of blast. Where stoves are placed at the top of the furnace, with chimnies above, there must undoubtedly be a relief beyond the ordinary exit of the blast against a wide column of atmosphere. Any arrangement which creates an exhaustion which will permit the blast to enter and pass through the materials more rapidly, is sure to increase make with economy of fuel. It will supply the heat of a greater force of blast, without the destructive actions of such a force.

Translated for the Journal of the Franklin Institute.

*Remarks on the Experiments made in* 1848 *and* 1849, *in the United States, by* Mr. S. C. Walker *and* Mr. O. M. Mitchel, *to determine the Velocity of Propagation of Electricity. By* M. H. Fizeau. (*Extract.*)

M. Gounelle and I presented to the Academy, at its session of 15th of April, 1850, a memoir on the velocity of propagation of electricity. Very extensive labors on the same subject were executed at the same time in the United States, by Messrs Walker and Mitchel. When we wrote our memoir, the first results of these researches were already known to us, but in too imperfect a way to render a detailed discussion possible. We could but mention them, and point out several causes of uncertainty which we saw in their experiments. New publications have given, in a pretty complete manner, the processes employed by the American observers, and the numerical results of their experiments. I present now, a detailed analysis of them, and it appears to me to be proved by this examination:

1st, That there existed in the modes of observation, several causes of constant or accidental errors, of which the authors had not taken account, and the effects of which are considerable, relative to the quantities which it is required to determine.

2nd, That the result of their observations was interpreted in a way contrary to the most probable theory of electric propagation.

3d, That the phenomena observed, are in no wise in contradiction with the velocity of propagation which we have deduced from our researches, which is 25,000 metrical leagues per second in iron wire.

4th, That this value may be deduced from the experiments given in the memoir of Mr. Mitchel.

5th, That the much less values given by the authors, and comprised between 12,000 and 5000 leagues per second, are not admissible.—*Comptes Rendus de l'Acad. des Sciences de Paris. 13th Janvier*, 1851.

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*Statistics of Coal Gas Used in England.**

The manufacture and consumption of coal gas alone is a wonder, in a commercial point of view. In England, 6,000,000 tons of coals are annually employed for its manufacture; and from 12,000,000*l.* to 15,000,000*l.* expended in its production. In London alone, 500,000 tons are consumed, producing 4,500,000 cubic feet of gas, and 500,000 chaldrons of coke—125,000 chaldrons of which are consumed in heating the retorts, and the remainder sold as fuel. The length of mains in London is 1600 miles, and the capital employed 4,000,000*l.*

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*Gas Retorts of Clay.*†

At the South Metropolitan Gas Works, in Old Kent road, there are now working two furnaces of retorts, with five in each, which have been uninterruptedly in action for 17 months. These retorts are made of fire-

* From the London Mining Journal, No. 806.
† From the London Mining Journal, No. 805.

clay, are D shaped, 7½ ft. long, 20 in. wide, by 7½ in. high. Each retort is calculated to have produced 1,800,000 cubic feet of gas, and there is every prospect of their making 2,000,000 ft. each of gas before they are worn out, without any increase in the expenditure of fuel. The manufacturers of these excellent specimens of fire-clay retorts are Messrs. Cowen and Co., of Blaydon Burn, near Newcastle-upon-Tyne.

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Translated for the Journal of the Franklin Institute.

*Note on a Method of Preserving Vegetable Alimentary Substances.* By M. Masson, *Chief Gardener of the Central Horticultural Society of France.*

After long researches, the first of which were ten years ago, the author has arrived at a simple and very practical method for drying vegetable substances, without altering their constitution, and for reducing them to a very small volume without losing their flavor and nutritious properties.

The process consists in drying them at a low temperature in stoves heated to about 95° Fahr., and in a very powerful compression by hydraulic press. The first operation deprives the substances of the superabundant water which is not indispensable to their constitution, and which for certain vegetables, such as cabbages and roots, amounts to more than 80 to 85 per cent. of their weight in the fresh state. The second reduces their volume, augments their density, making it equal to that of pine wood, and thus facilitates their preservation and stowage. To all vegetables thus prepared, it is sufficient to soak them in warm water from 30 to 45 minutes, when they reabsorb all the water which they had lost; they are then boiled for an hour or two, according to their nature, and seasoned in the usual way.

A number of experiments, made by the Navy Department, and detailed in reports, copies of which the author submits to the Academy, establish the quality and perfect preservation of these products after voyages of four years. In the space of 1 cubic metre, (a cube of 3·3 feet on each side,) 25,000 rations may be held.—(*Comptes Rendus de l'Academie des Sciences. 17th March*, 1851, *p.* 372.)

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## FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, May* 15, 1851.

S. V. Merrick, President, in the chair.
John F. Frazer, Treasurer.
Isaac B. Garrigues, Recording Secretary. } Present.

The minutes of the last meeting were read and approved.

Donations were received from The Royal Astronomical Society, London; A. C. Morton, Esq., Portland, Maine; W. Milnor Roberts, Esq., Marion, Ohio; Frederick Graff, Esq., Charles E. Smith, Esq., Oliver Byrne, Esq., Abraham Hunt, Esq., and the Apprentices' Library Company, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer read his statement of receipts and payments for the month of May.

The Board of Managers and the Standing Committees reported their minutes.

The following letter was read from Mrs. Sarah Peter, 1st Directress of the School of Design for Women, in reply to a letter from the Committee having charge of the School.

GENTLEMEN—In accepting the commission with which I am charged by your committee, which I shall fulfil to the utmost of my ability, I may be pardoned, from my known devotion to the interests of our School of Design, and in view of my approaching absence for many months, if I beg leave to subjoin a few observations respecting it.

Up to the present moment, the progress made by the students has surpassed the expectations of those who have had the care of them. Designs for calicoes, mouselines, &c., are executed in a style equal to corresponding patterns from abroad. Wood cuts are neatly finished, and designs for carpets, paper hangings, &c., &c., command already the approbation of competent judges. Lithographs, also, are produced of high merit—and attempts towards the establishment of an American School of Art has already begun.

Your Directors have furnished apartments superior to those afforded by most of the British schools, and the students manifest an ardour in their various pursuits, which, if duly encouraged, cannot fail to give to Philadelphia a preponderance in the tastefulness of its manufactures, beyond any in America—for be it remembered that in the greater number of the departments, especially those connected with wearing apparel and furnishing goods, *females* have everywhere excelled. See the Art Journal of London, and other European reports.

Thus it appears that in *production* we are advancing rapidly, yet something more is requisite. It is vain to accumulate port-folios of designs merely for the admiration of visiters. The object of the school is to furnish to manufacturers patterns, to be made up into the various fabrics for which they are intended; and as members of the same confraternity, the school looks to you as to its foster brethren, to sustain and encourage its early efforts, while at the same time, it will expect to advance your own interests.

Already orders are received from manufacturers in the States of New York, New England, and elsewhere, which give evidence that the merits of the school are better known and appreciated in the neighboring States than in our own. I therefore invite your attention to this fact, that you may henceforth be prepared to secure the earliest advantages of your own Institution; since it would be a matter of regret to all concerned, that strangers should bear away productions with which we would seek first to benefit our own townsmen, and adorn our own city. Allow me to add my conviction, that when you are made aware of the need of your co-operation, it will be at once liberally accorded.

Respectfully,

SARAH PETER,
*First Directress, &c.*

*Philadelphia, May* 14, 1851.

On motion, the Committee on Exhibitions were instructed to take the necessary steps to hold an Exhibition of American Manufactures next Fall, agreeably to their recommendation this evening.

New candidates for membership in the Institute (4) were proposed, and those proposed at the last meeting (6) were duly elected.

On motion, it was

*Resolved*, That the Committee on Publication be instructed to insert upon the cover of the Journal of the Franklin Institute, the following advertisement:

Corporations or individuals who may wish to employ Engineers, Draughtsmen, or Mechanics of any branch, are requested to make application, (post paid,) to the Actuary of the Franklin Institute.

*Resolved*, That upon the receipt of any such application, the Actuary shall cause it to be posted in a conspicuous part of the reading room.

Whereupon, any member who is not indebted to the Institute, upon application to the Actuary, shall be furnished with the address of the applicant.

Dr. Rand brought before the members the burner of M. Gaillard, which had been exhibited at the last meeting, as well as a modification of it made by Mr. Bishop, under the direction of Dr. Barclay, U. S. N. The light was produced from pure hydrogen, and the result was more satisfactory than on the previous trial. Dr. Barclay made some remarks on the low cost of the production of the hydrogen by the method of M. Gaillard.

Dr. Rand, in addition, presented some specimens of ivory carving, from the establishment of Messrs. E. & D. Ford, of Philadelphia. Part of the specimens were carved by hand, and others by machinery, and were exceedingly creditable specimens of the art. He also laid before the meeting a specimen of lithography, being the first of that branch of art, from the Female School of Design of the Institute.

Mr. J. C. Trautwine exhibited some specimens of argentiferous and common galena, from Phœnixville, Pa., and explained the difference in the mineralogical characters of the two varieties. Some specimens from this locality have proved very rich in silver, containing as much as 140 ounces to the ton.

Mr. J. V. Merrick exhibited to the meeting the model of the propeller attached to the steamer Albatross, designed by Mr. Ambrose W. Thompson. That propeller is 10 feet in diameter, and 26½ feet pitch outside. He called the attention of the members to the peculiar form of the blades, which are developed in a parabolic form, whether viewed in a direction parallel to that of the axis or radially. This peculiar conformation, it was claimed, caused every particle of water to be displaced in a line parallel to the axis.

He gave the dimensions of the vessel as follows: Length on deck, 191 feet; extreme breadth, 27 feet; depth of hold, 19 feet—the propelling power being given by two oscillating engines, with cylinders 40 inches diameter, and 40 inches stroke, attached to a shaft overhead, on which was a spur wheel gearing into a pinion on the propeller shaft, so that the latter made 1¾ revolutions to 1 of the engines. The usual number of revolutions attained was 32 per minute, giving, therefore, 56 to the propeller. The model exhibited had four blades, which formed the same angles at the hub and at the periphery.

Mr. Angus N. Macpherson presented a model (one-sixth size) of a pair of locomotive driving wheels, constructed entirely of wrought iron, designed by James Mulholland, Esq., Superintendant of Motive Power on the Philadelphia and Reading Railroad, and made by Mr. James Mullen, foreman blacksmith at the Reading Railroad depot, and made the following remarks: These wheels were intended for an express engine for the above named company's use. The model shows the method of pressing the various parts of the wheel previous to placing them in combined form, and also shows the method adopted for welding the various parts so as to make a solid mass.

There are twelve arms—upon one end of each there is attached a conical piece, which forms a section of the hub—to the other end is attached a portion of the periphery, forming a section of one-twelfth the entire rim. Those 12 pieces thus prepared, are placed together, and a disk welded on each side, forming the projection of hub. A series of V shaped pieces are welded into the periphery at the points of contact—the wheel is then bored at centre, and the circumference turned off, preparatory to receiving the tuyere hoop.

The attention of locomotive builders and others interested, is respectfully called to this method of constructing wheels, as it combines, in an eminent degree, strength, lightness, and elegance of appearance; and the cost is not so great as to preclude the adoption of them for general use.

The Water Gauge of Mr. Dilks for Steam Boilers was shown and explained by Prof. Frazer. It consists of a float attached to the long arm of a bent lever of very unequal arms; the fulcrum of which is upon a plug passing through the boiler at any convenient point above the highest water level. In the part of the plug inside of the boiler, are two separate chambers opening on the upper surface of the plug, and closed above by a flat slide valve, ground to fit the upper surface accurately. The chamber nearest the boiler head communicates with another passage drilled longitudinally from the outer end of the plug. The part of the plug which projects into the boiler beyond these chambers is hollow, and in the lower part of it the fulcrum of the float lever is supported, the smaller arm of the lever rising and being inserted into a slot in the back part of the slide. From the slide a pin projects downwards into the back chamber, and is connected with a wire passing through the longitudinal bore of the plug, and attached at its outer end to the short arm of a small lever, which serves as an index, working on a pivot attached to the outer end of the plug, and indicating on a plate bent into the arc of a circle, whose centre is the fulcrum of the index. The apparatus is so arranged that when the water is at the proper level the slide covers both chambers; when the water falls, the arm of the lever carrying the float is depressed, and the short vertical arm which works the slide, carries it backwards, and thus by means of the pin and wire indicates the change of the water level on the plate outside. When the water has fallen so low as to expose the boiler to danger, the motion of the slide opens the steam whistle chamber, and the steam issuing gives notice of this state of things. By the use of wires and bell-cranks, if necessary, an index may be connected with this apparatus, to show the state of the water in

the boiler at any distance from it, and thus permit the manager of any establishment using steam to know in his office at any moment the state of water in his boiler.

Prof. Frazer gave a brief account of the explosion of the steam boiler at Mr. Morris's works at Richmond, but as the subject was before the Committee on Science and the Arts, he made no allusion to any supposed cause of it.

An apparatus for demonstrating the rotation of the earth by means of the vibration of the pendulum, according to M. Foucault's plan, was explained and illustrated by Dr. C. M. Wetherill.

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## COMMITTEE ON SCIENCE AND THE ARTS.

### *Report on E. & T. Fairbanks & Co's. Weigh Lock, for Canals.*
### (*With a Plate.*)

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts, to whom was referred for examination an improvement on "Weigh Lock Scales," for Canals, by Messrs. E. & T. Fairbanks & Co., of St. Johnsbury, Vermont—REPORT:—

That they have visited and examined the weigh lock, erected on the Tide Water Canal, about twelve miles south of Columbia, and that its construction is as follows:—

The weight of the boat is supported upon a frame or cradle, which frame is suspended by 24 wrought iron rods, 12 on each side. The rods on either side are arranged in combinations of three, each three being supported by a separate main lever, of which there are eight. The rods do not, however, bear directly upon the main levers, but are supported intermediately upon what are called compensating levers, as is shown in the accompanying drawings, (Plate X.) It will be seen that the compensating levers are of the first order, having their arms in a ratio of 2 to 1; at the extremity of the longer arm, is attached one of the outer rods of the three, while from the shorter arm is hung in a similar manner, a shorter lever of the same kind, having equal arms, to each of which is attached one of the two other rods of the same set. The fulcrum of the first mentioned compensating lever hangs upon the main lever. This arrangement has been adopted for the purpose of allowing the rods to adjust their positions freely, so as to equalize the strains, and thus prevent the tendency to injure the form of the boat, which sometimes is found in more rigid constructions.

The main levers are of the second order, having the leverage in this case (about 16 to 1.) They are arranged in two sets of four in each set, and each set supports twelve rods, six on each side of the lock. The fulcrums are vertically over the side beams of the frame, while the free ends of the lever run diagonally inward, until those of each set nearly meet over the middle line of the cradle, where they rest by knife edge bearings in loops, hung from the extremity of another lever supported on the frame work above them. These last levers, of which there are two, are of the first order, with leverage of about 12½ to 1, and lie in a direction

parallel to the inner two of the main levers, extending inward from over the lock into the loft of the weighing house, where their free ends coming nearly together are connected with the weighing beam, by means of stirrups and rods extending downwards into the weighing office.

These ten levers (eight main levers and two upper ones) are made with broad side ribs, so that their transverse section has the form of a cross, and the main levers are moreover stayed, by means of a wrought iron truss rod, which is attached at the free end of the lever, and passing over the end of a strut projects downwards, under the point of attachment of the weight to the lever, passes up again and through the opposite end of the lever, where it is fastened by a screw and nut. The strut is not rigidly attached to the lever at its point of contact, but is capable of a slight rocking motion parallel to the lever; so that by merely screwing up the nut, the strain upon the truss may be increased at pleasure. The two upper levers have a double system of such trusses, on account of their great length (22½ feet.) The weight of the levers and cradle is counterbalanced by weights hung upon the prolongations of the upper levers beyond their fulcrums.

The weighing beam is a lever of the first order, having a graduated arm, capable with the counterpoise which slides upon it, of weighing 200 tons. The adjustment of the lever in balance, and of the position of its centre of gravity, is neatly and simply effected by a weight, which, while it is capable of sliding along an arm which is a projection of the weighing beam beyond its fulcrum, may also be raised or lowered in a vertical direction.

There is a notched side rib running along the beam, the notches of which correspond to the larger fractions of a ton, and a catch upon the counterpoise, which falls into these notches, to secure the accuracy of its position, while lesser fractions are obtained by a smaller counterpoise, which slides on a scale on the main one.

All the bearings of the apparatus are on steel knife edges. The advantages obtained by the arrangement thus described, are,

*First*, The accommodation of the bearing parts to the relative strains brought upon them, by means of compensating levers, so that there is no liability to irregular strains upon the boat, by which in the common arrangement they are sometimes injured, while at the same time, the apparatus is made sufficiently strong and rigid to fulfil its purpose properly.

*Secondly*, Increased rapidity and facility in weighing, by the substitution of the weighing beam and counterpoise, in place of the fixed scale and heavy weights, which have constantly to be removed and added with great labor on the part of the weighers.

*Thirdly*, Great accuracy in the determination thus rapidly obtained. The Committee saw that when a boat weighing 150 tons was in the cradle, the weight of a bucket of water placed on it, was plainly and at once indicated, and that the weight of a person standing on the boat, could be ascertained within a few pounds. They also satisfied themselves by actual experiment, that when a boat was twice weighed in different positions on the cradle, the two weights agreed precisely.

*Fourthly*, Durability in the apparatus, and great facility in removing any of the bearings which may have become injured.

In conclusion, the Committee were satisfied by their own observation, and the testimony of those who had the apparatus in daily and continual use, of the greatly increased efficiency of the weigh lock scale of the Messrs. Fairbanks & Co.; and they believe the greater part of the arrangement to be new. They therefore report it to be worthy of approbation, and recommend its general adoption.

By order of the Committee.

WILLIAM HAMILTON, *Actuary.*

*Philadelphia, January* 9, 1851.

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## BIBLIOGRAPHICAL NOTICES.

### *Pennsylvania Farm Journal.*

We hail with great pleasure the appearance of this new periodical, published under the auspices of the newly formed State Agricultural Society, and devoted to the interests of a great productive industry, which has hitherto not been sufficiently attended to within our borders. We have had, it is true, several agricultural publications of great value emanating from among us, but they have never spread among our farming population as they should have done, and their usefulness was consequently much diminished, by want of a free communication of mutual experience among our farmers. We hope that the present Journal will in this respect fare better, and that the State Agricultural Society and the Farm Journal, may do for the farmers of our State, what the Franklin Institute and its Journal have been for years trying to do (and not without success) for its mechanics. The Editor of the Journal, Prof. S. S. Haldeman, has been long and intimately known to us, and if enthusiastic devotion to science, habits of untiring industry, much valuable general information, great uprightness of character, and amiability of disposition, will qualify a man for the task which he has undertaken, it would not be easy to find within our State his superior. F.

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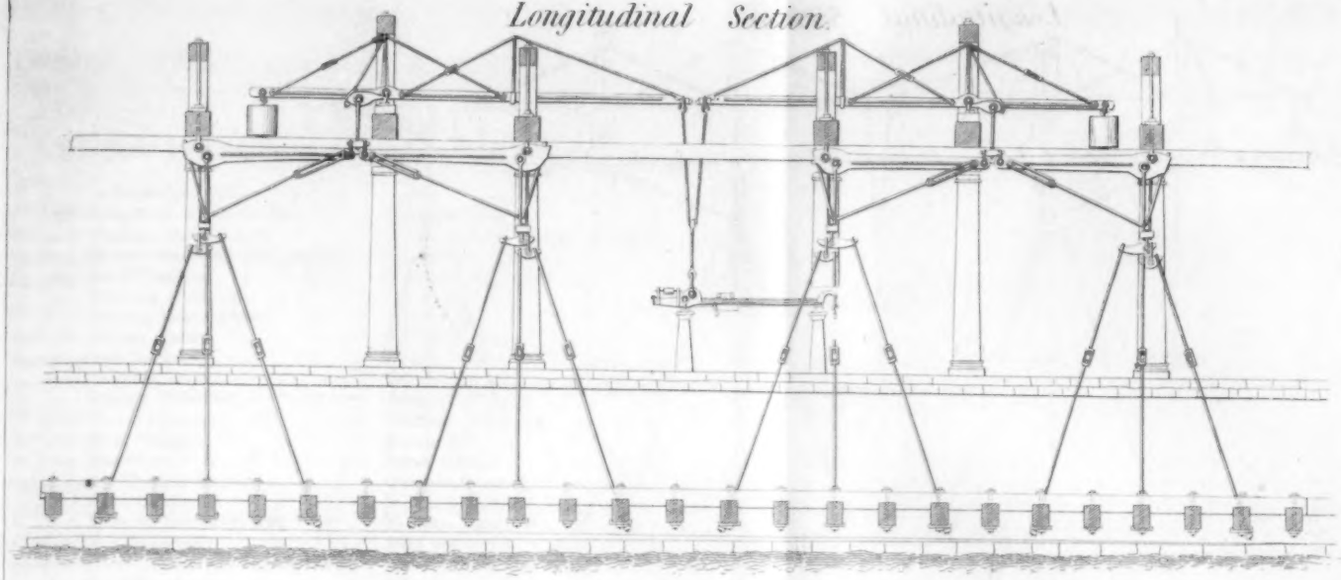
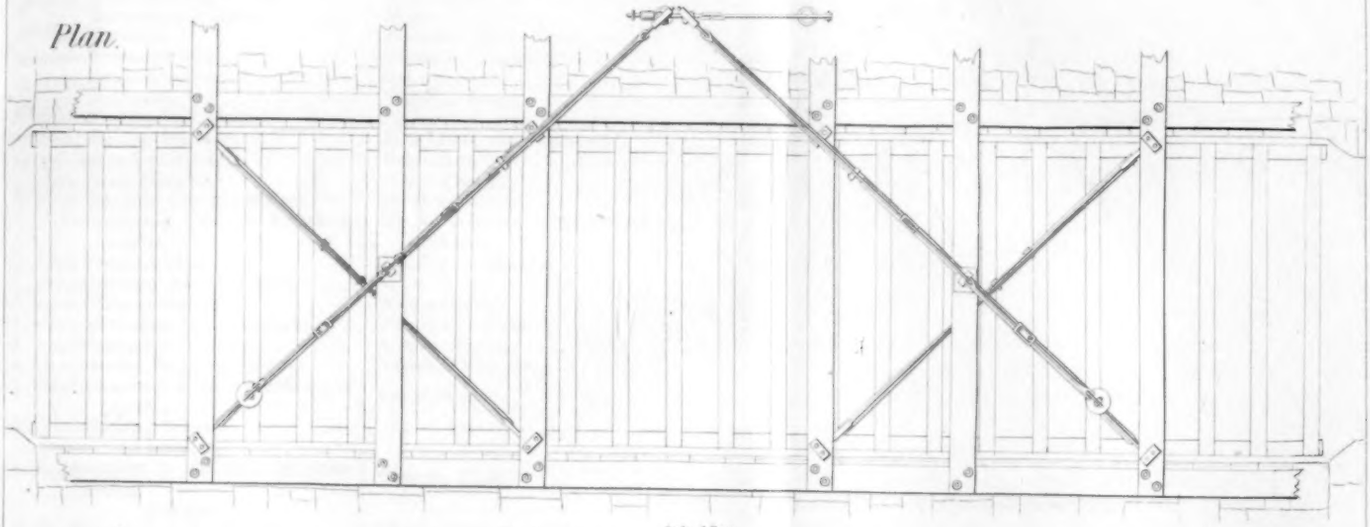
*The Year Book of Facts in Science and the Arts for* 1850. *By* JOHN TIMBS. *Reprinted from the London Edition. Philadelphia: A. Hart, late Carey & Hart.* 1851.

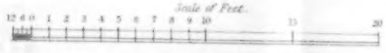
We are glad to find an American edition of this valuable little work, which gives within a very small limit, an epitome of the discoveries and improvements in Science and the Arts within the year, and the reference to the authorities from which further information can, if desired, be obtained. Of course, a book of this kind cannot claim any higher merit than that of a judicious selection from the overwhelming amount of claimed discoveries and improvements in Science and Art which a year gives rise to, but that merit this volume appears to have in a high degree, and to be very well deserving of patronage. ED.

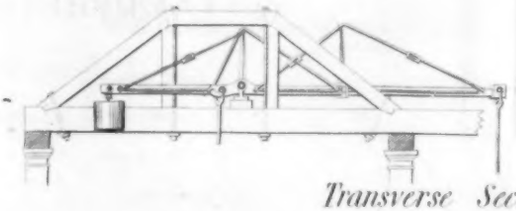
*Longitudinal Section.*



*Plan.*





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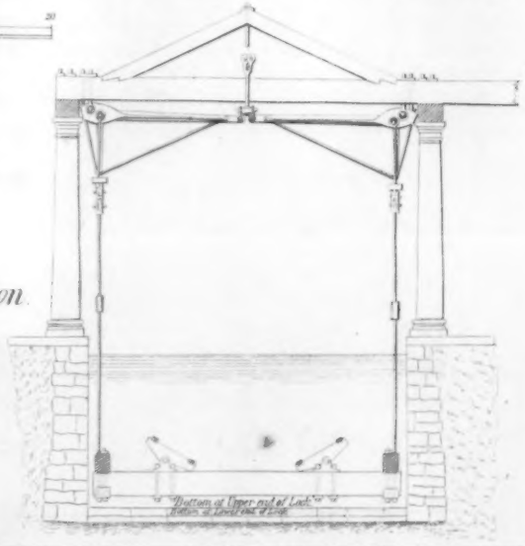

**E. & T. FAIRBANKS & Co's**

**WEIGH LOCK FOR CANALS.**

# INDEX.

## LIST OF AMERICAN PATENTS, WITH REMARKS, &c.


| | | | Page. |
|---|---|---|---|
| *November*, 1850. | | | |
| 17. | Improvement in Filter for Oils, | Thomas Antisell, | 12 |
| 18. | —— Making Jack Chains, | C. Atwood and George Kellogg, | ib. |
| 19. | —— Electro-Magnetic Telegraphs, | Charles S. Bulkley, | ib. |
| 20. | —— Seed Planters, | Samuel Cannon, | 13 |
| 21. | —— Printing Machines, | Oliver T. Eddy, | ib. |
| 22. | —— Making Horse Shoes, | Samuel S. Greene, | ib. |
| 23. | —— Drying Paints, | Aquilla Jones, | ib. |
| 24. | —— Iron Railings, | J. & C. Krauser & S. Crowell, | 14 |
| 25. | —— Cooking Stoves, | Samuel Pierce, | ib. |
| 26. | —— Sewing Machines, | Allen B. Wilson, | ib. |
| 27. | —— Gun Harpoons, | William Albertson, | ib. |
| 28. | —— Bake Ovens, | Hosea Ball, | 15 |
| 29. | —— Bee Hives, | Jarvis Case, | ib. |
| 30. | —— Air Heating Furnaces, | Gardner Chelson, | ib. |
| 31. | —— Corn Shellers, | David Eldridge, | ib. |
| 32. | —— Mills for Grinding, &c., | William Frost, | ib. |
| 33. | —— Bell Telegraph, | John Garvey, | 16 |
| 34. | —— Photographic Pictures on Glass, | Frederick Langenheim, | ib. |
| 35. | —— Handling Augers, | John E. Larkin, | ib. |
| 36. | —— Plate Printing Presses, | E. C. Middleton, E. Nevers, & R. Neale, | ib. |
| 37. | —— Excavating Machines, | Martin Newman, Jr., | 17 |
| 38. | —— Pessaries, | Jonathan Hovey Robinson, | ib. |
| 39. | —— Extension Tables, | Edwin F. Shoenberger, | ib. |
| 40. | —— Spark Arresters, | Samuel Swett, | ib. |
| 41. | —— Bedsteads, | Wilhelm Raiser, | ib. |
| 42. | —— Feeding Nail Plates, | Frederick J. Ayres, | 18 |
| 43. | —— Planing Machines, | E. G. Allen and C. Briggs, | ib. |
| 44. | —— Ship Ventilators, | Ralph Bulkley, | ib. |
| 45. | —— Gang Ploughs, | Henry Cowing, | 19 |
| 46. | —— Hanging Carriage Bodies, | M. G. Hubbard, | ib. |
| 47. | —— Rendering Cordage Uninflammable, | M. Y. Johnson, administrator to J. H. Johnson, | ib. |
| 48. | —— Fountain Pens, | Charles W. Krebs, | ib. |
| 49. | —— Securing Rail-road Rails, | H. H. Mary, | ib. |
| 50. | —— Sausage Stuffer, | Simon McNair, | ib. |
| 51. | —— Threading Wood Screws, | Thomas J. Sloane, | ib. |
| 52. | —— Repeating Fire Arms, | Joshua Stevens, | 20 |
| 53. | —— Shuttle Motion in Looms, | Thomas T. Willcox, | ib. |
| 54. | —— Combined Boiler, Cupola, and Grate, | Loftis Wood, | ib. |
| 55. | —— Cooking Stoves, | do. do. | ib. |
| | RE-ISSUE. | | |
| 1. | Improvement in Turning Irregular Forms, | Timothy Clark, | 20 |
| | DESIGNS. | | |
| 1. | For Bas-relief of Henry Clay, | Charles Younglove Haynes, | 21 |
| 2. | —— Stoves, | R. J. Blanchard, as'd. Learned & Thatcher, | ib. |
| 3. | —— Parlor Air-Tight Stoves, | A. Richmond, assg'nd to Barstow & Co. | ib. |
| 4. | —— Stoves, | D. Root, | ib. |
| 5. | —— Carriage Plates, | J. S. Royce, | ib. |
| 6. | —— Spoon Handles, | C. P. & G. B. Gordon, | ib. |
| 7. | —— Stoves, | W. B. Gleason, as'd. Hartshorne & Ames, | ib. |
| *December*, 1850. | | | |
| 1. | Improvements in Turning Irregular Forms, | Smith Beers, | 22 |

| | | | |
|---|---|---|---|
| 2. | Improvement in Boring Mortices, | Henry J. Betjemann, | 22 |
| 3. | —— Alarm and Indicator for Steam Engines, | Joseph Dilks, | ib. |
| 4. | —— Tin Cutting and Bending Machines, | William H. Horton, | ib. |
| 5. | —— Casting Large Kettles, | William Kelly, | ib. |
| 6. | —— Dressing Spokes, | Orville Mather, | 23 |
| 7. | —— Nail Machines, | Melville Otis, | ib. |
| 8. | —— Horse Rakes, | Harvey W. Sabin, | ib. |
| 9. | —— Suspender Buckles, | Elisha Steele, | 24 |
| 10. | —— Auger Handle, | Augustus Thayer, | ib. |
| 11. | —— Vulcanizing India Rubber, | Jonathan T. Trotter, | ib. |
| 12. | —— Balance Boiler Feeder, | Willam D. Allen, | ib. |
| 13. | —— Harness Buckles, | Solon Bingham, Jr. | 25 |
| 14. | —— Bearings for Axles and Shafts, | William H. Hovey, | ib. |
| 15. | —— Lever Jacks, | James Leffel, | ib. |
| 16. | —— Electrotyping, | George Mathiot, | ib. |
| 17. | —— Seed Planters, | Samuel and Morton Pennock, | 26 |
| 18. | —— Do. do. | Dexter B. Rhodes, | ib. |
| 19. | —— Sewing Machines, | Frederick R. Robinson, | ib. |
| 20. | —— Two and Three Ply Carpets, | Alexander Smith, | 27 |
| 21. | —— Indicating Depth of Water in Vessels, | Henry B. Sommers, | ib. |
| 22. | —— Planing Machines, | Daniel H. Southworth, | ib. |
| 23. | —— Manufacturing Flour, | J. White and J. Bundy, | ib. |
| 24. | —— Making Pill Boxes, | Nelson D. White, | 28 |
| 25. | —— Motion for Puppet Valves, | Samuel H. Gilman, | ib. |
| 26. | —— Seed Planters, | J. Signer and T. N. Shipton, | ib. |
| 27. | —— Mills for Sawing with Circular Saws, | Orlando Child, | 96 |
| 28. | —— Doubling and Twisting Silk, | J. Conant and L. Dimock, | ib. |
| 29. | —— Emptying Privies, | Florimond Datichiry, | ib. |
| 30. | —— Carriages, | E. and C. Everett, | 97 |
| 31. | —— Cutting and Bending Sheet Metal, | Joseph F. Flanders, | ib. |
| 32. | —— Seed Planters, | Joseph W. Fawkes, | ib. |
| 33. | —— Expansion Gear for Engines, | Samuel H. Gilman, | ib. |
| 34. | —— Making Eyelets, | L. E. Hicks, ass'd. to Churchill & Stanley, | ib. |
| 35. | —— Grain Cradle Fingers, | Joel Houghton, | 98 |
| 36. | —— Sash Fasteners, | William H. Lazelle, | ib. |
| 37. | —— Arrangement of Steam Engine, | R. F. Loper and J. W. Nystrom, | ib. |
| 38. | —— Making Cores for Castings, | Edward Reese, | ib. |
| 39. | —— Mills for Grinding, | John Rogers, Jr., | ib. |
| 40. | —— Seeding Cylinders, | David E. Rohr, | 99 |
| 41. | —— Curves of Ship Timbers, | Charles Scales, | ib. |
| 42. | —— Artificial Legs, | W. C. Stone, | ib. |
| 43. | —— Lamps for Lighting Gas Burners, | Robert Thompson, | ib. |
| 44. | —— Fanning Mills, | Eleazer Bless, | ib. |
| 45. | —— Making Starch from Maize, | Thomas Bragg, | ib. |
| 46. | —— Damping Paper for Copying Presses, | Joseph Burnham, | 100 |
| 47. | —— Planing Machines, | Thomas H. Burridge, | ib. |
| 48. | —— Hydraulic Blowers, | Jeremiah Darling, | ib. |
| 49. | —— Vats for Tanning, | Lewis C. England, | 101 |
| 50. | —— Printing Presses, | Charles W. Hawkes, | ib. |
| 51. | —— Operating Window Blinds, | John Jones, | ib. |
| 52. | —— Pumps for Wells, | William D. Mayfield, | ib. |
| 53. | —— Instrument for Vaccinating, | Henry Mellish, | 102 |
| 54. | —— Casting Hollow Hinges, | John C. Parry, | ib. |
| 55. | —— Port Folios, | James Shaw, | ib. |
| 56. | —— Weaving Figured Fabrics, | S. T. Thomas & E. Everett, | ib. |
| 57. | —— Mills for Grinding, | Joseph N. Walker, | 103 |
| 58. | —— Hot Air Furnaces, | George E. Waring, | ib. |
| 59. | —— Weighing Grain, | Samuel R. Wilmot, | ib. |

RE-ISSUE.

| | | | |
|---|---|---|---|
| 1. | Improvement in Railroad Carriages, | C. Davenport and A. Bridget, . | 181 |

DESIGNS.

| | | | |
|---|---|---|---|
| 1. | For Cook Stoves, . . . | S. Pierce, as'd. to Johnson, Cox & Fuller, | 181 |
| 2. | —— Stoves, . . . | M. Smith and B. S. Gleason, . | ib. |
| 3. | —— Air-tight Cooking Stoves, . | Charles A. Lambard, . | ib. |

*January*, 1851.

| | | | |
|---|---|---|---|
| 1. | Improvement in Daguerrotype Pictures, | Charles J. Anthony, . . | 104 |
| 2. | —— Car Couplings, . . | Silas M. Cochran, . . | ib. |
| 3. | —— Lead Pipe Machine, . | John B. Collan, . . | ib. |
| 4. | —— Planing Machines, . . | William E. Cornell, . . | ib. |
| 5. | —— Water Metres, . . | John Ericsson, . . | 105 |
| 6. | —— Churns, . . . | Daniel Fisher, . . | ib. |
| 7. | —— Steam Engines, . . | Samuel H. Gilman, . . | 106 |
| 8. | —— Assorting Broom Corn, . | Lorenzo D. Grosvenor, . | ib. |
| 9. | —— Quilting Frames, . . | Abraham Kaufman, . . | ib. |
| 10. | —— Carriage Wheels, . . | J. Lamb and C. H. Root, . | ib. |
| 11. | —— Candlesticks, . . | James Manning, . . | ib. |
| 12. | —— Weaving Seamless Bags, . | Shelden Northrop, . . | 107 |
| 13. | —— Seed Planters, . . | James P. Ross, . . | ib. |
| 14. | —— Printing Presses, . . | Stephen P. Ruggles, . | ib. |
| 15. | —— Turning Irregular Forms, . | Jonathan Russell, . . | 108 |
| 16. | —— Manufacture of India Rubber, . | Jonathan T. Trotter, . | ib. |
| 17. | —— Corn Shellers, . . | Joshua M. C. Armsby, . . | ib. |
| 18. | —— Spring Mattresses, . | David Baird, . . | ib. |
| 19. | —— Rotary Pumps, . . | Thomas Bennet, . . | 109 |
| 20. | —— Weaving Tapestry Carpets, | Erastus B. Bigelow, . | ib. |
| 21. | —— Fountain Inkstands, . . | Francis Draper, . . | ib. |
| 22. | —— Jointing Staves, . . | William Maguire, . | 110 |
| 23. | —— Lock for Fire Arms, . . | Stanhope W. Marston, . . | ib. |
| 24. | —— Grain Harvesters, . | Edward Neely, . . | ib. |
| 25. | —— Electro-Magnetic Engines, . | Jacob Neff, . . | ib. |
| 26. | —— Arches in Bridge Trusses, | Cunningham M. Pennington, | ib. |
| 27. | —— Coal Stoves, . . | James Shields, . . | 111 |
| 28. | —— Parallel Vices, . . | Samuel R. Simpson, . . | ib. |
| 29. | —— Ox Yokes, . . | Andrew L. Simpson, . | ib. |
| 30. | —— Repeating Fire Arms, . . | James Warner, . . | ib. |
| 31. | —— Manufacture of Caviar, . | Robert G. Westacott, . | 112 |
| 31. | —— Tires for Railroad Car Wheels, | Theodore T. Abbott, . . | 173 |
| 32. | —— Raising Carriage Tops, . | John L. Allen, . . | ib. |
| 33. | —— Weaving Piled Fabrics, . | Erastus B. Bigelow, . . | ib. |
| 34. | —— Connecting, &c., Hubs and Axles, | A. M. Billings, . . | 174 |
| 35. | —— Tuyeres, . . . | Joseph Dorwart, . . | ib. |
| 36. | —— Rotary Pumps, . . | J. Stuart Gwynne, . | ib. |
| 37. | —— Changing Reciprocating into Rotary Motion, . . | Joseph Harris, Jr., . . | ib. |
| 38. | —— Cast Iron Car Wheels, . | George R. McFarlane, . . | ib. |
| 39. | —— Reflectors for Street Lamps, . | Hugh and James Sangster, . | 175 |
| 40. | —— Steering Apparatus, . | Joseph E. Andrews, . . | ib. |
| 41. | —— Carriages, . . . | John Jones, . . | ib. |
| 42. | —— Propeller, . . . | Ambrose W. Thompson, . | ib. |
| 43. | —— Brick Presses, . . | Jacob Scheitler, . . | ib. |
| 44. | —— Stoves, . . . | George H. Thatcher, . . | 176 |
| 45. | —— Convertible Plough Stocks, . | Edward T. Parker, . | ib. |
| 46. | —— Embossing Books, . | Charles Starr, . . | ib. |
| 47. | —— Lee-Way Indicator, . . | A. A. Wilder, . . | ib. |
| 48. | —— Making Horse Shoe Nails, | D. Wilson, Ass'd to Wilson & Bird, | 177 |
| 49. | —— Stoves, . . . | Elihu Smith, . . | ib. |
| 50. | —— Patterns for Castings, . | Francis N. Still, . . | ib. |
| 51. | —— Abdominal Supporters, . | Moses L. Knapp, . . | ib. |
| 52. | —— Swivel Nibbed Key, . | James Hanley, . . | ib. |
| 53. | —— Hydraulic Ram, . . | William Field, Jr., . . | ib. |
| 54. | —— Spinning Machines, . | Newell Wyllys, . . | 178 |
| 55. | —— Pens for ruling Paper, . | Alfred Hathaway, . | ib. |

RE-ISSUES.

| | | |
|---|---|---|
| 1. Improvement in Bending Felloes for Wheels, | Edward Reynolds, | 178 |
| 2. —— Sofa Beadstead, | Russell Scarrett, | 179 |
| 3. —— Folding paper, | Edward N. Smith, | ib. |
| 4. —— Making Mouldings, | Alfred T. Serrill, | ib. |
| 5. —— Sewing Machines, | S. C. Blodget and J. A. Lerow, | 180 |

DESIGNS.

| | | |
|---|---|---|
| 1. For Cook Stoves, | William C. Davis, | 180 |
| 2. —— Stoves, | C. Gilbert and W. G. Hallman, | ib. |
| 3. —— do. | Elihu Smith, | ib. |
| 4. —— do. | Joseph G. Lamb, | ib. |
| 5. —— do. | S. W. Gibbs, as'd to North & Harrison, | ib. |
| 6. —— Cooking Stoves, | do. do. Jagger, Treadwell, and Perry, | 181 |
| 7. —— Parlor do. | C. Harris, and P. W. Zoiner, | ib. |

*February*, 1851.

| | | |
|---|---|---|
| 1. Improvement in Lard Lamps, | Delamar Kinnear, | 181 |
| 2. —— Obtaining Motive Power, | William M. Storm, | 182 |
| 3. —— Cooking Stoves, | Backus A. Beardsley, | ib. |
| 4. —— Preparing Hides, | Thomas W. Jones, | ib. |
| 5. —— Check Power Looms, | Enoch Burt, | 183 |
| 6. —— Ship's Light, | Leonard Goodrich, | ib. |
| 7. —— Grain Harvesters, | Sidney S. Hurlbut, | ib. |
| 8. —— Scraper, | C. Schofield and G. J. Johns, | ib. |
| 9. —— Seeding Apparatus, | S. and M. Pennock, | ib. |
| 10. —— Sewing Machines, | W. O. Grover and W. E. Baker, | 184 |
| 11. —— Hydraulic Rams, | John Osborn, | ib. |
| 12. —— Plank in Pavements, | Joseph E. Ware, | ib. |
| 13. —— Fusible Plug for Steam-Boilers, | E. H. Ashcroft, | 233 |
| 14. —— Annular Steam Boiler, | Thomas Champion, | ib. |
| 15. —— Hand Looms, | Isaac H. Garretson, | 234 |
| 16. —— Turning Irregular Forms, | Philo S. Beers, | ib. |
| 17. —— Tools for Tonguing, Jointing, &c. | John A. Fry, | ib. |
| 18. —— Weavers' Heddles, | Charles Tiot Judkins, | 235 |
| 19. —— Opening and Closing Doors, &c. | William Post, | ib. |
| 20. —— Snatch-Block, | Philip Rhodes, Jr., | ib. |
| 21. —— Planing Machines, | Daniel H. Southworth, | ib. |
| 22. —— Saw Mills, | Isaac Straub, | ib. |
| 23. —— Raising and Carrying Water, | James D. Willoughby, | 236 |
| 24. —— Knitting Machines, | J. Pepper, as'd. to Warren and Sanford, | ib. |
| 25. —— Cooking Ranges, | Moses Pond, | ib. |
| 26. —— Musical Instruments, | Marvin Smith, | 237 |
| 27. —— Friction Rollers to Axles, | J. B. & S. Wilson, | ib. |
| 28. —— Planing Machines, | J. D. Beers and I. Winston, | ib. |
| 29. —— Electro-Magnetic Engines, | Thomas C. Avery, | ib. |
| 30. —— Iron Buildings, | Joseph Banks, | 238 |
| 31. —— Sad Irons, | Edward Clapp, | ib. |
| 32. —— Spring Hinge, | Theodore F. Englebrecht, | ib. |
| 33. —— Extension Tables, | Francis Hoguet, | ib. |
| 34. —— Cooking Stoves, | William Sours, | ib. |
| 35. —— Turning Irregular Forms, | Abner Lane, | ib. |
| 36. —— Spring Hinges, | H. W. Sabin and G. Drew, | 239 |
| 37. —— Feeding, &c. Screw Blanks, | Thomas J. Sloan, | ib. |

RE-ISSUES.

| | | |
|---|---|---|
| 1. Improvement in Tanning Leather, | H. Hibbard, as'd. to W. W. Reid, | 239 |
| 2. —— Steam Boilers and Furnaces, | H. Boardman, | ib. |

DISCLAIMER.

| | | |
|---|---|---|
| 1. Improvement in Making Wire Heddles, | Abijah J. Williams, | 245 |

DESIGNS.

| | | |
|---|---|---|
| 1. For Cooking Stoves, | Samuel A. House, | 240 |
| 2. —— Parlor Stoves, | do. do. | ib. |
| 3. —— Umbrella Stands, | E. J. Delany, as'd. to Heins & Adamson, | ib. |
| 4. —— Cooking Stoves, | S. H. Sailor, as'd. Warnick, Leibrandt & Co. | ib. |

*March*, 1851.

| | | | |
|---|---|---|---|
| 1. | Improvement in Paper Moulds, | Wm. Brewer and John Smith, | 240 |
| 2. | —— Power Governors, | Junius Judson, Jr. | ib. |
| 3. | —— Calculating Machines, | John W. Nystrom, | 241 |
| 4. | —— Steam Boilers, | Bernard O'Neill, | ib. |
| 5. | —— Peppermint Dropper, | Henry H. Snow, | ib. |
| 6. | —— Cut-off for Steam Boilers, | Henry Waterman, | ib. |
| 7. | —— Dressing Mill Stones, | Edmund P. Gaines, | ib. |
| 8. | —— Trip Hammers, | Luther Briggs, Jr., | 242 |
| 9. | —— Climbing Poles, | Henry D. Chapman, | ib. |
| 10. | —— Cast Iron Car Wheels, | Perry G. Gardiner, | ib. |
| 11. | —— Making Tires, | do. do. | ib. |
| 12. | —— Connecting Truck with Car Bodies, | Thomas P. How, | ib. |
| 13. | —— Slides in Bee Hives, | Nathaniel Potter, | ib. |
| 14. | —— Window Curtain Fastenings, | Hugh Guyer, | 243 |
| 15. | —— Steam Drilling Machines, | Joseph W. Fowle, | ib. |
| 16. | —— Air-tight Franklin Stoves, | Rensselear D. Granger, | ib. |
| 17. | —— Daguerreotypes in Monumental Stones, | Solon Jenkins, | ib. |
| 18. | —— Cooking Stoves, | James Greer and Rufus J. King, | 244 |
| 19. | —— Piano Forte Action, | John Ruck, | ib. |
| 20. | —— Turning, Boring, &c., | Martin and Thomas R. Way, | ib. |
| 21. | —— Copying Presses, | A. A. Wilder, | 245 |
| 22. | —— Teeth of Saws, | George F. Woolston, | ib. |
| 23. | —— Trunk Handles, | Elijah A. Andrews, | 307 |
| 24. | —— Weaving Parti-Colors, | Erastus B. Bigelow, | 308 |
| 25. | —— Jacquard Looms, | do. do. | ib. |
| 26. | —— Fastening Scythe Snaths, | E. S. Clapp, | ib. |
| 27. | —— Curry Combs, | James M. Gardner, | ib. |
| 28. | —— Adjustable Cut-Off, | Samuel H. Gilman, | 309 |
| 29. | —— Cylinders for Looms, | Eliakim M. Hastings, | ib. |
| 30. | —— Scythe Fastenings, | Ebenezer G. Lamson, | ib. |
| 31. | —— Jacquard Machines, | John Scott and John Tannahell, | ib. |
| 32. | —— Bee Hives, | Albert J. Surles, | 310 |
| 33. | —— Handles of Sad Irons, | T. R. Timby, | ib. |
| 34. | —— Metallic Buildings, | Simon Willard, | ib. |
| 35. | —— Ploughs, | G. Heffley, S. Conrad & J. Wigle, | ib. |
| 36. | —— Securing Shutters, | Charles W. Krebs, | ib. |
| 37. | —— Sash Lock, | Michael Norton, | ib. |
| 38. | —— Extension Tables, | Lewis Thorn, | 311 |
| 39. | —— Securing, &c. Shutters, | N. W. Speers, | ib. |
| 40. | —— Drawing, &c. Liquids, | Richard F. Stevens, | ib. |
| 41. | —— Scythe Fasteninge, | Nathaniel Lamson, | ib. |
| 42. | —— Preparing Clay for Bricks, | Heman Whipple, | ib. |
| 43. | —— Upright Piano Fortes, | Henry Klepfer, | ib. |
| 44. | —— Scythe Fastenings, | Nathaniel Lamson, | ib. |
| 45. | —— Balance Valves, | Francis B. Stevens, | 312 |

RE-ISSUES.

| | | | |
|---|---|---|---|
| 1. | Improvement in Carriages, | John Jones, | 312 |
| 2. | —— Cutting Stones, | Charles Wilson, | ib. |
| 3. | —— Fire Arms, | William W. Hubbell, | ib. |
| 4. | —— Evaporators and Condensers, | Edward Lynch, | ib. |
| 5. | —— Covering Hams, | Horace Billings, | ib. |
| 6. | —— Cleaning Rags, | James Phelps, | 313 |

DESIGNS.

| | | | |
|---|---|---|---|
| 1. | For Furnace Register, | Gardner Chilson, | 313 |
| 2. | —— do. do. | do. do. | ib. |
| 3. | —— do. do. | do. do. | ib. |
| 4. | —— do. do. | do. do. | ib. |
| 5. | —— a Six Plate Stove, | S.W. Gibbs, as'd Jagger, Treadwell & Co. | 314 |
| 6. | —— a Cooking Stove, | do. do. do. do. | ib. |
| 7. | —— do. do. | John S. Perry, | ib. |
| 8. | —— Air-Tight Box Stove, | S.W. Gibbs, as'd. Jagger, Treadwell & Co. | ib. |

| | | | |
|---|---|---|---|
| 9. | For Pedestals and Columns, | Wm. and Wm. H. Lewis, | 314 |
| 10. | —— Parlor Grates, | Joseph Pratt, | ib. |
| | *April*, 1851. | | |
| 1. | Improvement in Folding, &c. Cloth, | Henry Boot, | 314 |
| 2. | —— Making Horse Shoe Nails, | Marshall Burnet, | 315 |
| 3. | —— Sticking Pins on Paper, | Chauncey O. Crosby, | ib. |
| 4. | —— Wheat Fans, | John Hollingsworth, | ib. |
| 5. | —— Grinding Paints and Drugs, | Gilbert D. Jones, | ib. |
| 6. | —— Rice Hullers, | Peter McKinlay, | 316 |
| 7. | —— Blasting Rocks, | Charles Monson, | ib. |
| 8. | —— Forming Locks, | Jabez Walker, | ib. |
| 9. | —— Wheat Fans, | Jesse White, | ib. |
| 10. | —— Bran Dusters, | John M. Carr and James Hughes, | ib. |
| 11. | —— Connecting, &c. Wheels and Axles, | Simeon Heywood, | ib. |
| 12. | —— Manufacture of India Rubber, | David M'Curdy, | 317 |
| 13. | —— Splint Machines, | Henry Mellish, | ib. |
| 14. | —— Seed Planters, | Archibald Wieting, | ib. |
| 15. | —— Screws for Bedsteads, | H. Gross and W. Campbell, | ib. |
| 16. | —— Stone and Metal for Paving, | George H. Knight, | ib. |
| 17. | —— Brick Presses, | John J. Riddle, | ib. |
| 18. | —— Sawing Machines, | Pearson Crosby, | 318 |
| 19. | —— Fastening Table-Leaves, | Lewis J. Mason, | ib. |
| 20. | —— Brick Presses, | J. Z. A. Wagner, | ib. |
| 21. | —— Bolting Flour, | L. Fagan & H. C. Hayman, | ib. |
| 22. | —— Saw Set, | Elijah S. Holkins, | 319 |
| 23. | —— Setting up Ten Pins, | Thomas J. Sloan, | ib. |
| 24. | —— Horse Power, | Aaron D. Crane, | ib. |
| 25. | —— Making Jack Chains, | W. Todd, as'd. to Attwood & Kellogg, | ib. |
| 26. | —— Ladies' Work Tables, | Celia R. P. Foster, | ib. |
| 27. | —— Grain Separators and Fans, | Roswell T. Merrill, | ib. |
| 28. | —— Saw Set, | Hiram Strait, | 320 |
| 29. | —— Winnowing Machines, | Jonathan L. Booth, | ib. |
| 30. | —— Cooking Stoves, | Rufus K. Pain, | ib. |
| 31. | —— Scythe Fastenings, | Oliver Clark, | ib. |
| 32. | —— Calico Printing, | Charles A. Broquette, | ib. |
| 33. | —— Milling Tools, | Buckingham & Baird, ass'd to Scoville Manufacturing Co. | 321 |
| 34. | —— Mill Stones, | E. T. Hanon Valcke, | ib. |
| 35. | —— Iron Railings, | John Krauser, | ib. |
| 36. | —— Steam Engines, | R. F. Loper & J. W. Nystrom, | ib. |
| 37. | —— Cooking Stoves, | James S. Marsh, | ib. |
| 38. | —— Window Curtain Fixtures, | S. S. Putnam, | 322 |
| 39. | —— Setting Saw Logs, | John W. Robbins, | ib. |
| 40. | —— Agitating Grate Bars, | Abraham D. Spoor, | ib. |
| 41. | —— Paper Boxes, | Andrew Dennison, | ib. |
| 42. | —— Window Blind Slats, | Samuel Avery, | ib. |
| 43. | —— Ornamenting Marble, | Henry Hoffman & Charles F. Hill, | 323 |
| 44. | —— Cooking Stoves, | Dennis G. Littlefield, | ib. |
| 45. | —— Glazed Sheet Iron, | John & Wm. W. Wood, | ib. |
| 46. | —— Correcting, &c., Sight, | Jonathan Ball, | 380 |
| 47. | —— Cooking Stoves, | Charles W. Grannis, | ib. |
| 48. | —— Gutta Percha Tubing, | James Reynolds, | ib. |
| 49. | —— Stretching Leather, | Bradford Rowe, | ib. |
| 50. | —— Clogs or Pattens, | Charles W. Stearns, | 381 |
| 51. | —— Stretching Leather, | Wm. Strevell & Daniel Brown, | ib. |
| 52. | —— Tapered Metallic Rods, | Wm. Clay, | ib. |
| 53. | —— Saw Mills, | L. Hedge, ass'd. to G. W. Hedge, | ib. |
| 54. | —— Coffee Roasters, | Edward Whiteley, | 382 |
| 55. | —— Straw Cutters, | Tazwell F. Wingo, | ib. |
| 56. | —— Car Seats, | R. Stilwell and E. L. Brundage, | ib. |
| 57. | —— Lock and Key, | J. R. Bugbee, ass'd. Bugbee & Robinson, | ib. |
| 58. | —— Smut Machine, | Jehu Hollingsworth, | ib. |
| 59. | —— Metallic Door, | Ira L. Cady, | 383 |

60. Improvement in Winnowing Machines, Oliver Etnier, . . . 383
61. —— Spring Saddles, . . Joseph C. Smith, . . ib.
62. —— Writing, . . . J. G. Goshon & W. H. Towers, . ib.
63. —— Making Matches, . . Ira H. Smith, . . ib.
64. —— Making Horse Shoes, . Robert G. Babcock, . . ib.
65. —— Bats for Felting, . . Leander W. Boynton, . 384
66. —— Splint Machines, . . Lewis L. Gilliland, . . ib.
67. —— Float for Vessels, . . Wm. Mt. Storm, . . ib.

RE-ISSUE.

1. For Improvement in Doubling, Twisting, &c., Thread, . } Frank Cheney, . . ib.

DESIGNS.

1. For Parlor Grates, . . W. Ames, ass'd. to Hartshorn & Ames, 384
2. —— Air-Tight Stoves, . . N. P. Richardson, . . 385
3. —— do. do. . . Frederick Shultz, . . ib.
4. —— Stoves, . . . J. Williams, ass'd. Williams, Bird & Co. ib.
5. —— Cooking Stoves, . . S.W. Gibbs, as'd. Jagger, Treadwell & Co. ib.
6. —— do. do. . . Dutee Arnold, . . ib.
7. —— do. do. . . John Abendroth, . . ib.
8. —— Bust of Jenny Lind, . . Thomas Ball, . . . ib.

*May*, 1851.

1. Improvement in Lock and Key, . Linus Yale, Jr. . . 385
2. —— Meat Cutting Machines. . Thomas Vanderslice, . . ib.
3. —— Exploding Harpoons, . Charles Burt, . . ib.
4. —— Hand Logs, . . J. R. St. John, as'd. to Renwick, Barnard & St. John, . . 386
5. —— Manufacture of India Rubber, . Nelson Goodyear, . . ib.
6. —— Bedstead Fastenings, . J. R. Kain & S. L. Tiffin, . ib.
7. —— Spark Arrester, . . James A. Cutting, . . ib.
8. —— Pumps, . . . Nelson Newman, . . 387
9. —— Lime Kilns, . . . Richard A. Schroeder, . ib.
10. —— Making Ice, . . John Gorrie, . . . ib.
11. —— Illuminating Gas, . . F. Joseph de Cavaillon, . ib.
12. —— Assorting Screw Blanks, . Thomas J. Sloan, . . 388
13. —— Straw Cutters, . . Jonathan Sullivan, . . ib.
14. —— Aquatic Velocimeters, . John R. St. John, . . ib.
15. —— Planing Machines, . . R. & C. S. Bixby and John Garst, ib.
16. —— Steering Wheels, . . Charles Hoskins, . . ib.
17. —— Indicators for Steam Boilers, . George Faber, . . 389
18. —— Flouring Apparatus, . James M. Clark, . . ib.
19. —— Hinge of Doors, Shutters, &c. Ezra Ripley, . . ib.
20. —— Setting Teeth, . . Adolph F. Ahrens, . . ib.
21. —— do. do. . . do. do. . . ib.
22. —— Brick Presses, . . John Grant, . . . 390
23. —— Saw Mills, . . . Martin Fairfield, . . ib.

Æronautic Ascension of Messrs. Barral and Bixio—Journal of the . 34
Albumonizing Photographic Glasses, . . . . 125
Algeria—Public Works at . . . . . 232
Anthracite Coal—Description of a Boiler for generating Steam by the burning of 390
Antimony—Experiments on the Thermo-Electric Power of Crystalized Bismuth and 39
Artificial Leg—Notice of Yerger & Ord's . . . 213
Assaying and Mining—Notice of Overman's Practical Mineralogy, . 288
Austria—Statistics of Railways in . . . 6
Axles—On the Form of Shafts and . . . 56

Beams for Steam Engines—Wrought Iron . . . 232

BIBLIOGRAPHICAL NOTICES.

Chemistry—Experiments illustrating the Science of—By G. Francis, . 69
Coast Survey of the United States—Annual Report of the . 359
Iron in Pennsylvania—Documents relating to the Manufacture of . 69
Mineralogy, Assaying and Mining. By F. Overman, . 288
Pennsylvania Farm Journal, . . . 432

Statics—Elementary Treatise on. By G. Monge, . . 216
Storms—Development of the Law of—By Col. Reid, . 68
Year Book of Facts in Science and the Arts, in 1850—J. Timbs . 432

Bismuth and Antimony—Experiments on the Thermo-Electric Power of Crystalized 39
Bitumen from Pictou—Analysis of . . . 212
Blast Furnaces—On the Economical Application of the waste Gases from 204, 324, 421
——— On the use of Caustic Lime instead of Limestone in 255, 259, 260, 327, 329
——— On the Conduction of Heat in . . 259
Boiler for generating Steam by the burning of Anthracite—Description of a 390
——— Improved Locomotive . . . . 6
Boilers of Sea Steamers—Advantages of using Fresh Water in the . 88
Bridge—Description of a Plate Iron Girder . . . 230
——— Failure of the South-Eastern Station, London, . 85
——— History and Construction of the Britannia . . 299
——— on the York, New Castle, and Berwick Railway—Description of the Royal Border . . . . 305

Calculating Machine—Description of Nystrom's . . 262
Canal between the Mediterranean and the Red Sea—Ship . 85
——— Commissioners of the State of Pennsylvania—Annual Report of the 161
Canals—Report on Fairbanks & Co's. Weigh Lock for . . 430
Caoutchouc and Gutta Percha—Improvement in dissolving . 198
Chemical Action of Oxygen—Influence of Light on the . . 124
Chimney of the Edinburgh Gas Works—An Account of the . 158
Chimnies—On the Consumption of Smoke from Furnaces and 64
Coal Gas used in England—Statistics of . . 425
——— Lands—Remarks on the Dauphin and Susquehanna . . 142
Coals used in the Collins' Tubular Boiler—On the Economic Value of 135
Coast Survey of the United States—Notice of the Annual Report of the . 359
Collieries Theoretically and Practically considered—The Ventilation of 228
Collins' Line of Steam Ships—Notice of . . 414
Colors upon Tissues—On the method of fixing . . 133
Condensers for Marine Steamers—On Fresh Water . . 124
Cornish Engines in the United States—Notice of the . . 353
———, Statistics of the . . 91, 172, 229, 305
Curves for Railroads—On the Field Practice of Laying out Circular 361

Dauphin and Susquehanna Coal Lands—Remarks on the . . 142
Dimpfel's (F. P.) Boiler for Generating Steam by the Burning of Anthracite—Description of . . . . 390
Distances—Apparatus of M. Groetars for Measuring Inaccessible . 379
Dry Dock at Brooklyn—Description of the Naval . . 135
——— Philadelphia—Notice of the Sectional . . 353

Earth by means of the Pendulum—Physical Demonstration of the Rotation of the 350
East India Railway—Notice of the . . . 232
Electric Telegraph—First Idea of the . . . 202
——— Notice of the Copying . . 200
Electricity—Remarks on Experiments to determine the Velocity of Propagation of 425
Electro-Magnetic Telegraph—Dr. Turnbull's Lectures on the . 190, 267, 330
Engineer—Query—What constitutes an . . . 55
Engineers—The way to make . . . . 95
Engines—Notice of Oscillating . . . 419
Exhibition Building—Construction of the Roof of the great . 76
——— Description of the Design and Construction of the London 185
Explosion from Surcharged Steam—Boilers on the Oven plan liable to 166
——— of Stationary Steam Boiler, in Philadelphia . . 66
——— at Halifax, . . 127, 203
——— of the Boiler of the Queen Steamer . . 30
——— Steam Boat Anglo Normon . 51
——— Steamer Knoxville, at New Orleans, . 205
Explosions of Steam Boilers—Extracts from Dr. J. L. Smith's Lecture on the Causes and Prevention of . . . 407

Farm Journal—Notice of the Pennsylvania . . . 432
Fawn—Report on the Passages of the Mail Screw Steamer . . 397
Ferns, Sea Weeds, &c.—Method of Producing Plates for Printing . 220
Fire Arms—Specification of W. W. Hubbell's Improvement in . 323
—— Box for Burning Anthracite Coal in Locomotives—Experiment on De Haven's 138
Flax Manufacture, . . . . . 62
Flue of the Tamar Silver Lead Mines—Enormous . . . 84
France—Statistics of Steam Power in . . . . 227
Furnaces and Chimnies—On the Consumption of Smoke from . 64
———— On the Conduction of Heat in Blast . . 259
———————— Economical Application of the Waste Gases from Blast 204, 324, 421
———————— Use of Caustic Lime instead of Limestone in Blast 255, 259, 260, 327, 329

FRANKLIN INSTITUTE.

Proceedings of Stated Meetings, . 65, 141, 210, 275, 280, 354, 426

*Committee on Science and the Arts.*

Report on G. Faber's Magnetic Gauge for Steam Boilers, . 215
———— Fairbanks & Co's. Weigh Locks for Canals . 430

Galvanized Type—Remarks on Dr. Newton's . . . 280
Galvano-Plastics—Preparation of Sponging Metallic Lead and its application to 197
Gas available for Illuminating purposes—Remarks on Gaillard's Burners for rendering Hydrogen . . . . . 355, 428
— Retorts of Clay . . . . . 425
— Used in England—Statistics of Coal . . 425
— Works—an account of the Chimnies of the Edinburgh . . 158
———— Annual Report of the Philadelphia . . 289
Gases from Blast Furnaces—On the economical application of the Waste 204, 324, 421
—— On the Magnetic and Dia-magnetic condition of . . 60
Gauge for Steam Boilers—On J. Dilk's Water . . . 429
Geological Map of France—Notice of the . . . 356
Germany—Statistics of Telegraphs in . . . 34
Glass Painting—Directions for Mixing Colors for Tinting in . . 122
Great Britain—Railway Travel in . . . . 5
———— Remarks on the Statistics of the Cotton Manufactures in . 29
Groetar's (M.) Apparatus for Measuring Inaccessible Distances, . 379
Gutta Percha—Improvement in Dissolving Caoutchouc and . . 198
———— Tissue as an Insulator for Electricity—Remarks on the use of 359

Heat in Blast Furnaces—On the Conduction of . . . 259
—— of Water—Latent . . . . 189
Hydraulic Machinery and Steam Engines—Description of Thompson's 342
———— Mortar as made and used at the Liverpool Docks . . 131
Hydrogen Gas available for Illuminating purposes—Remarks on Gaillard's 355

Ice—Quantity of Heat which becomes Latent in Melting of . 189
— Variation in the Melting point of . . . 197
Illuminating Purposes—Remarks on Gaillard's Burners for Rendering Hydrogen Gas available for . . . . . 355
Inaccessible Distances—M. Groetar's Apparatus for Measuring . 379
Incrustations in Steam Boilers—Method of Preventing . . 224
India Rubber and Gutta Percha—Improvement in Dissolving . 198
Indigo—Method of ascertaining the value of . . . 123
Iron Beams for Steam Engines—Wrought . . . 232
—— Girder Bridge—Description of a Plate . . . 230
Isherwood, (B. F.)—On Indicator Diagrams from the U. S. War Steamer Spitfire 91
———————— On the U. S. War Steamer Spitfire . . 168
———————— Notes on the U. S. Steamship Michigan . 217

Jacobi, (Prof.) Obituary notice of . . . 358
Jones, (A. C.)—On the Explosion of the Steam Boat Aglo-Normon . 51
———————————— Steamer Knoxville . . 205

Lamp—Description of Hadrot's Mechanical . . . 341
Latent Heat of Water . . . . . 189
Lafayette—Notice of the Steam Ship . . . . . 420
Lead and its application to Galvano-Plastics—Preparation of Spongy Metallic 197
Light as a substitute for Gas—the Voltaic . . . . 131
—— on the Chemical Action of Oxygen—Influence of . 124
Lime instead of Limestone in Blast Furnaces—On use of Caustic 255, 259, 260, 327, 329
Locomotive Boiler—Improved . . . . . 8
———— Driving Wheels—on J. Mulholland's . . . 429
———— Engines—Experiments with De Haven's Fire Box for Burning Anthracite Coal in . . . . 138
———— Remarks on the Cost of the Repairs of . 80, 145
———— Steam Carriage for Common Roads . . . 229
Locomotives on High Gradients—Means of Augmenting the Ascensive Power of 152
Magnetic Gauge for Steam Boilers—Report on G. Faber's . 215
——— Telegraph—Turnbull's Lectures on the Electro- . 190, 267, 330
———— Notice of Morse's . . . . 354
Map of France—Notice of a Geological . . . . 356
Marble Sawing and Polishing by Machinery . . . . 246
Marine Steamers—Notice of . . . . . 419
Mercury by Overheated Steam—On the Distillation of . . 48
Meridian for all Nations—Common . . . . 126, 200
Mineralogy, Assaying, and Mining—Notice of F. Overman's Practical 288
Monumental City—Notice of the Steamer . . . 418
Mortar as made and used at the Liverpool Docks—Hydraulic . 130

Naval Dry Dock at Brooklyn—Description of the . . 135
Navigation—Ocean . . . . . 41
———— of the River Seine—Improvements in the . . 73
———— on Shallow Rivers—Notes on Steam . . 150
Nystrom's (J. W.) Calculating Machine, . . . . 262
———— Screw Propeller—Description of . . 345

Obituary Notice of Professors Jacobi and Oersted, . . 358
Ocean Navigation—The Cunard and Collins' Lines . . 41
Oscillating Engines—Notice of . . . . 419
Oxygen—Influence of Light on the Chemical Action of . . 124
Ozone—Dr. Hare's Remarks and Experiments on . . 283

Paddle Wheels—On the Vertical and Radial . . . 49
Paint—Remarks on Oxide of Zinc . . . . 67
Painting—Directions for Mixing Colors for Tinting in Glass . 122
Patent Law—Alterations in the English . . . 124
Pendulum—Physical demonstration of the Rotation of the Earth by means of the 350
Pennsylvania—Annual Report of the Canal Commissioners of the State of 161
Pennsylvania Farm Journal—Notice of the . . . 432
Pens—Statistics of the Manufacture of Steel . . . 129
Photogenic Glasses—Albumenizing . . . . 125
Photographic Positive Pictures directly on Paper—New Process for obtaining 134
Photometric Process—Account of M. Pernot's . . 203
Printing Ferns, Sea Weeds, &c.—Method of producing Plates for . 202
Propeller—Description of J. W. Nystrom's Screw . . 345
Propellers—Discussion on the relative merits of Paddle Wheels and Screw . 275
———— Query respecting Screw . . . 41
———— between Philadelphia and Liverpool—Steam . . 139
Public Works at Algeria, . . . . 232

Railroad Car—Description and Performance of L. Myer's Revolving . 143
———— Company—Report of the Vermont Central . . 1
Railroads—On the Field Practice of Laying out Circular Curves for . 361
Railway Accidents—Statistics of . . . . 307
———— Carrying Stock—On . . . . . 153, 294
———— Frightful Collision on the Lancaster and Yorkshire . 87
———— Management—A Novelty in . . . . 228

Railway Notice of the East India . . . . 232
——— Passenger Assurance Company . . . 95
——— Traffic—Statistics of . . . . 222, 225
——— Travel in Great Britain, . . . . 5
Railways in Austria—Statistics of . . . . 6
——— in the World—Statistics of the . . . 227, 305
——— Means of Augmenting the Ascensive Power of Locomotives on 152
River Seine—Improvements in the . . . . 73
Roof of the Great Exhibition Building—Construction of the . 76
Rotation of the Earth by means of the Pendulum—Phyical demonstration of the 350

Screw Propeller—Description of J. W. Nystrom's . . 345
—— Propellers—Discussion on the Relative Merits of Paddle Wheels and . 275
——————— Query Respecting . . . . 41
—— Steamer Fawn—Report of the Voyages of the Mail . . 397
Sea Weeds, &c.—Method of Producing Plates for Printing Ferns . 202
Seine—Improvements in the River . . . 73
Shafts and Axles—On the form of . . . . 56
Smoke from Furnaces and Chimnies—On the Consumption of . 64
Statics—Notice of Monge's Treatise on . . . 216
Steam Boat Anglo-Norman—Explosion of the . . . 51
——————— Inspection—Present System of . . 30
——————— Shafts—Remarks on the Method of Faggoting . . 287
——— Boiler—Description of Champion's Annular . . 274
——— Boilers—General Rule for Proportioning the Length of Stationary . 164
——————— Lecture on the Causes and Prevention of the Explosions of 407
——————— Method of Preventing Incrustations in . . 224
——————— On the Adhesion of Safety Valves of . 171
——————— On J. Dilk's Water Gauge for . . 429
——————— On the Economic Value of Coals used in the Collins' Tubular 135
——————— On the Oven plan liable to Explosion . . 166
——————— Report on G. Faber's Magnetic Gauge for . 215
—— by the burning of Anthracite—Description of a Boiler for generating . 350
—— Carriage for Common Roads—Clark and Motley's Locomotive 229
—— Engines—Description of Thompson's Hydraulic Machinery and . 342
——————— Wrought Iron Beams for . . 232
—— in the Engines of the South Staffordshire Iron District—On the condension of 114
—— Log of the Steamer British Queen, . . . 140
—— Marine Navy—New Bill to prevent Accidents in the English . 172
—— Navigation on Shallow Waters—Notes on . . 150
—— On the distillation of Mercury by overheated . . 48
—— on the Upper Danube, . . . . 39
—— Power in France—Statistics of . . . 227
—— Propellers between Philadelphia and Liverpool, . . 139
—— Ship Building—English and American . . 41
——— Michigan—B. F. Isherwood's Notes on the United States . 217
Steam Ship Lafayette—Notice of the . . . 420
—— Ships—Notice of the Collins' Line of . . 414
Steamer Albatross—Notes on the Ship and her Propeller . 428
——— Explosion of the Boiler of the Queen . . 30
——— Spitfire—Notes on Indicator Diagrams from the United States War 91
——————— Notes on the United States War . . 168
Steamer Monumental City—Notice of . . . 418
——— Pacific from Liverpool—Quick Passage of the . 421
Steamers—Notice of Marine . . . 419
——— Advantages of using Fresh Water in the Boilers of Sea . 88
——— Carribbean and Brother Jonathan—Notice of the New York 354
——— On Fresh Water Condensers for Marine . . 124
Sugar—On Detonating . . . . 123

Telegraph—Dr. Turnbull's Lectures on the . . 190, 267, 330, 401
——— First Idea of the Electric . . . 202

**Telegraph—Notice of the Copying Electric** . . . . 200
**——————— Morse's Magnetic** . . . 354
**Telegraphs in Germany—Statistics of** . . . . 34
**Telescope—Description of a new Arrangement of Reflecting** . . 112
**Tissues—On a Method of fixing Colors upon** . . . . 133
**Trautwine (J. C.) on the Field Practice of Laying Out Circular Curves for Railroads** 361
**Types—Remarks on Dr. L. V. Newton's Galvanized** . . 280

**Valves of Steam Boilers—On the Adhesion of the Safety** . 171
**Vegetable Alimentary Substances—Note on a method of Preserving** 426
**Ventilating Hospitals, Factories, or Workhouses,** . . 75
**Ventilation of Collieries Theoretically and Practically considered,** . 228
**Vermont Central Railroad Company—Report of the** . . 1
**Voltaic Light as a substitute for Gas Light,** . . . 131

**Water—On the Latent Heat of** . . . . 189
**—— Gauge for Steam Boilers—On J. Dilk's** . . 429
**Weigh Lock for Canals—Report on Fairbanks & Co's.** . 430
**Wheels and Screw Propellers—Discussion on the Relative Merits of Paddle** 275
**——— On J. Mulholland's Locomotive Driving** . . 429
**——— On Vertical and Radial Paddle** . . . . 49

**Year Book of Facts in Science and the Arts in 1850—J. Timbs** . 432

**Zinc Paint—Remarks on Oxide of** . . . 67

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